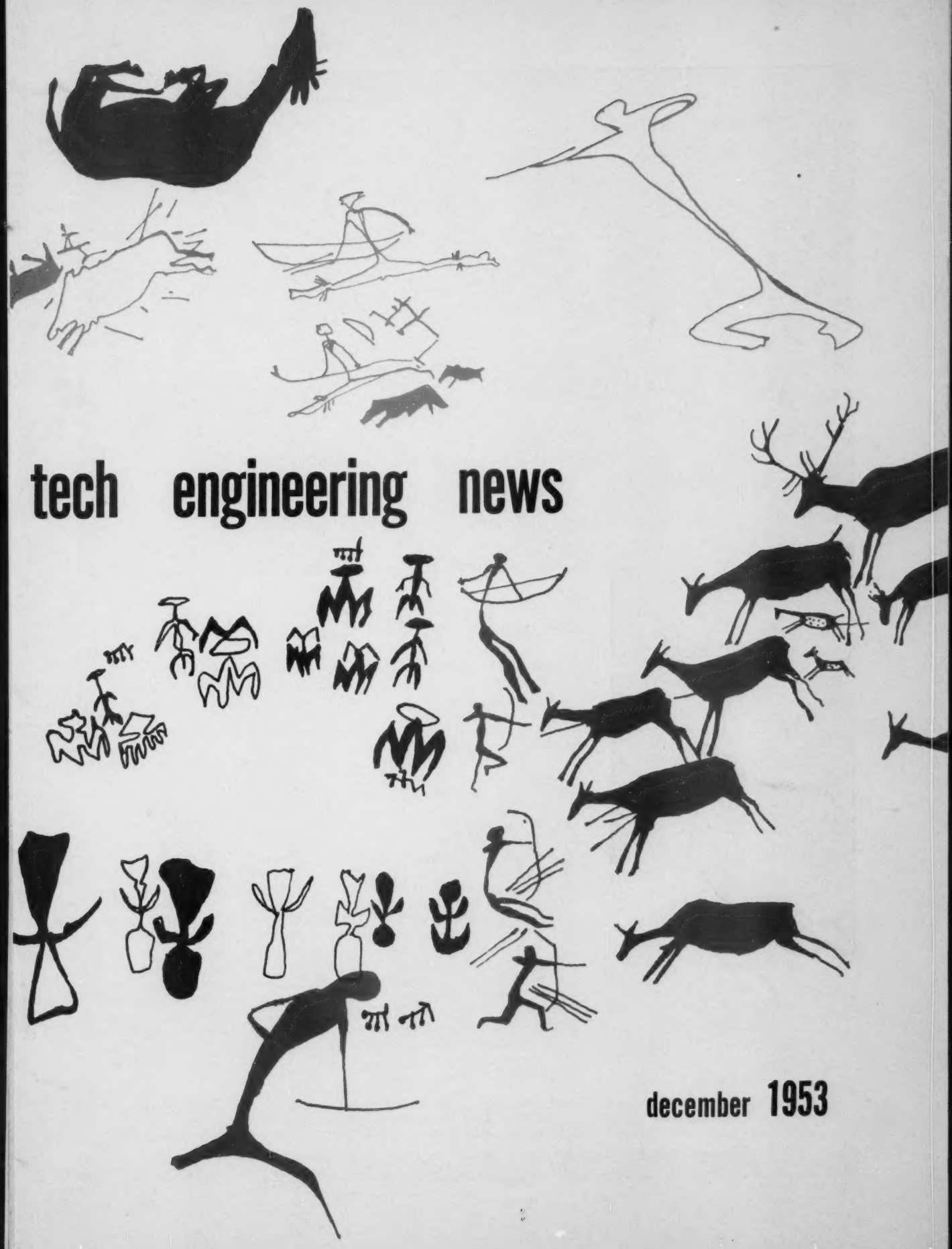


tech engineering news

december 1953

. . . but one does more!

HERE you see two pieces of steel. They are the same size, the same shape, the same weight. Although they look exactly alike, one of these steels is far more valuable—in terms of what it can do.

It's the piece on the right—one of the U·S·S High Strength Steels—and it has greater strength than the ordinary carbon steel shown on the left. This means that with U·S·S High Strength Steel you can reduce the weight of a railroad car, a truck, a bus, or of many other steel products . . . *without reducing their strength.*

U·S·S High Strength Steel in a ¼" thickness can frequently be substituted in a design which uses ⅜" ordinary carbon steel, without sacrificing strength in the equipment.

Or—you can work it this way. Simply use U·S·S High Strength Steel in the *same* thickness as ordinary carbon steel. Then, equipment will be stronger and more rugged . . . but it will weigh no more!

Furthermore, one of these high strength steels—U·S·S COR-TEN—has high resistance to atmospheric corrosion—4 to 6 times that of plain steel. Think what this means in increased life!

Very fine, you say, but what will all this cost? Well, here's the real pay-off. Surprisingly enough the products improved with U·S·S High Strength Steels usually cost no more . . . because pound for pound the steel does more. Its slightly higher initial cost per pound is often offset by the fact that less steel is needed. And, in the long run, many products made from these better steels actually cost less because they last longer, and are cheaper to operate and maintain.

USS HIGH STRENGTH STEELS — UNITED STATES STEEL — 1933 1953 — TWENTY YEARS OF PERFORMANCE

Developing special steels for special customer needs is an important job of United States Steel metallurgists and engineers. With their tremendous background of practical experience, they are ready to work on any problem that involves the more efficient use of steel. United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pa.

UNITED STATES STEEL

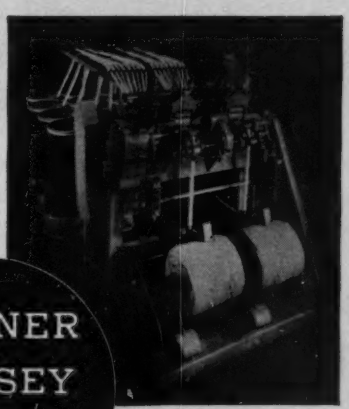
"Friendly" government vs. "selfish" business

THE GOVERNMENT will carry a letter for you from Texas, say, to New York for 3¢. But the government loses money on the trip, and you have to pay taxes to make up the difference.

Business carries a gallon of gasoline the same journey from Texas to New York for 1/5th of 3¢, does it almost as fast. It may not be door-to-door delivery, but it's a lot harder to handle, in spite of which business makes a profit—and out of which it pays taxes to support government business ventures such as the post office.

Since time began, the hope of private profit is what has stimulated the drive for efficiency and low costs, out of which everyone benefits. If that is business selfishness, the world needs more of it.

Warner & Swasey is always interested in talking future opportunities to young men of ability and character. Write Charles Ufford.



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Pin Drafter processing wool for yarn

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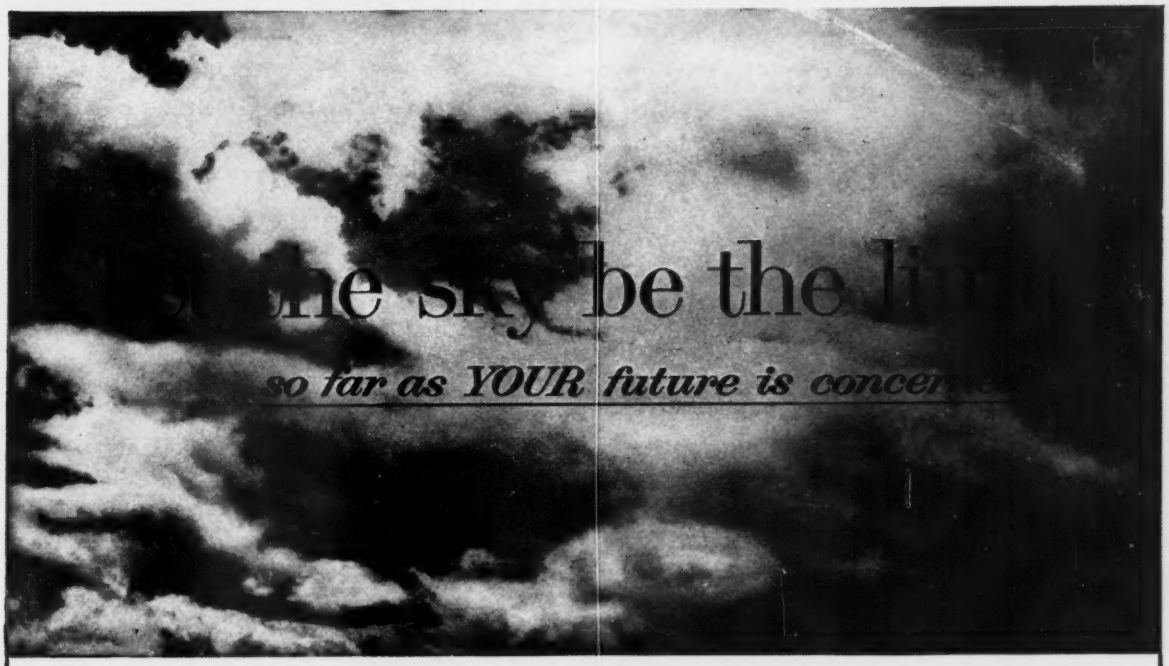
Wallace Barnes Springs

Springmakers for four generations

Bristol Connecticut



NEVER has the future been so inviting for young engineers as that awaiting them today in the field of aeronautics.

And never have the opportunities been so promising as those offered at Goodyear Aircraft Corporation.

The reasons for this are twofold.

VERSATILITY is the keynote at Goodyear Aircraft, offering you the widest latitude for your engineering talents. Here is taking place pioneer research and development of guided missiles, bonded sandwich structures, plastics for radomes and cockpit canopies, metals and metal-working techniques for the production of fuselage shells, fuel tanks, wheels and brakes and countless airplane components.

Goodyear is America's only producer of both heavier- and lighter-than-air craft.

STABILITY is a priceless advantage of working with Goodyear, for it is a leader in one of America's basic industries—a place that will always be doing business come defense, peace or war.

Put the two together and you have opportunities unlimited and a future assured.

WE INVITE YOU TO WRITE for our booklet "Plan Your Career At Goodyear Aircraft"—and, if you desire, to accompany your request with a brief resumé of your qualifications or experience.

ADDRESS: Dr. K. Arnstein, Vice President of Engineering, Goodyear Aircraft Corporation, Akron 15, Ohio.

GOODYEAR
AIRCRAFT
Akron, Ohio

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FRONTISPIECE

Iron

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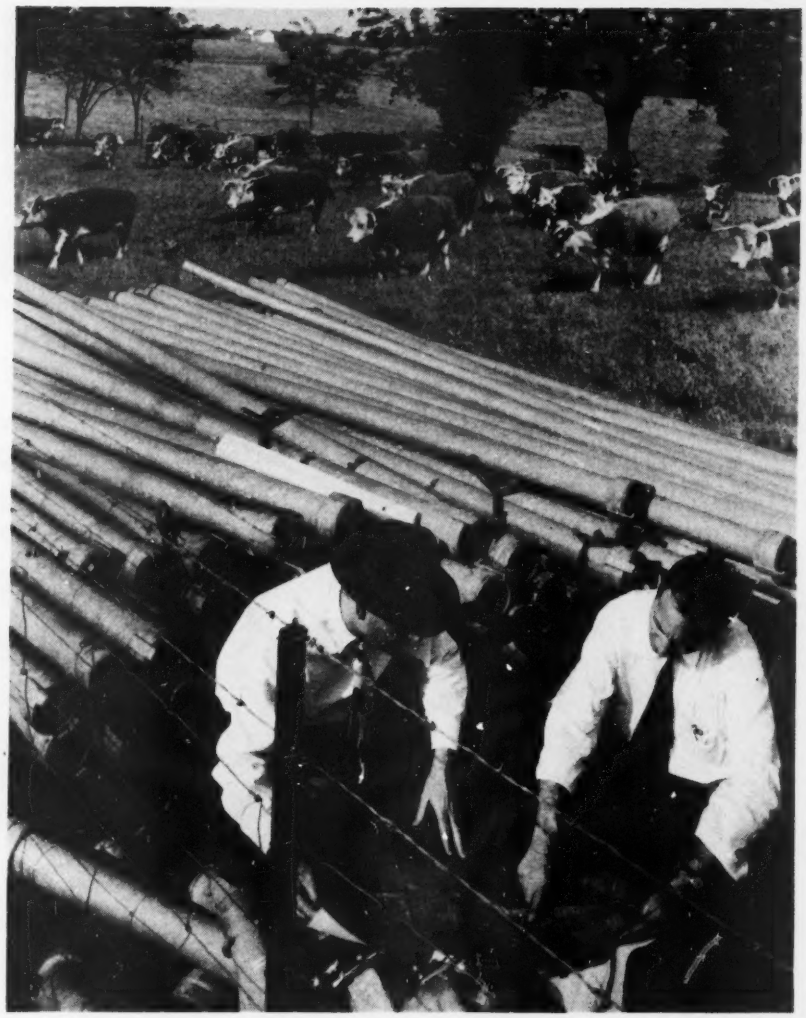
Two agricultural scientists, from a large state university, check the blue print for irrigation pipe on Republic's experimental farm.



HERE THE CATTLE ARE GUINEA PIGS

If you're going into industry, one of your most difficult tasks faces you in the next few months. You'll have to distinguish between progressive companies and stand-stills. One way is to consider the pioneering each is doing.

How much does this company you might join plan its future?

How much does it care about society in general?

The cattle in the picture, for instance, are at Republic's experimental farm. They are part of a study to determine how much extra grass, hence extra meat, can be produced by irrigation. The purpose of the experiment is to prove the benefit of converting worn-out crop land to profitable grazing area.

The economic reasons for Republic's experiment are that animals must be fenced and Republic makes steel farm fence; also that irrigation requires pipe and Republic makes steel irrigation pipe. But beyond this immediate commercial aspect, Republic's experimental farm has a goal reaching far into the future.

Republic Steel's policy is based on a deep realization that no economic or social section of a nation can long progress at the expense of others. Progress must be mutual and industry has a responsibility to *do for* its customers as well as to *sell to* them. This, we believe, is an enlightened approach to economics which will promote the continuing welfare of all.

We hope such research programs, of which our farm experiments are only one example, will catalog Republic in your mind as a progressive, forward-thinking company.

REPUBLIC STEEL

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REPUBLIC STEEL

WORLD'S WIDEST RANGE OF STEELS AND STEEL PRODUCTS

There's great new opportunity for Engineers in Honeywell's growing Aeronautical Division

The delicately balanced glass of water below clings to its perch, despite the plane's sharp banking turn.

That's because a Honeywell electronic autopilot is in command . . . the human pilot nowhere near the controls.

So precisely are the control surfaces coordinated, that all displacing forces are instantly equalized.

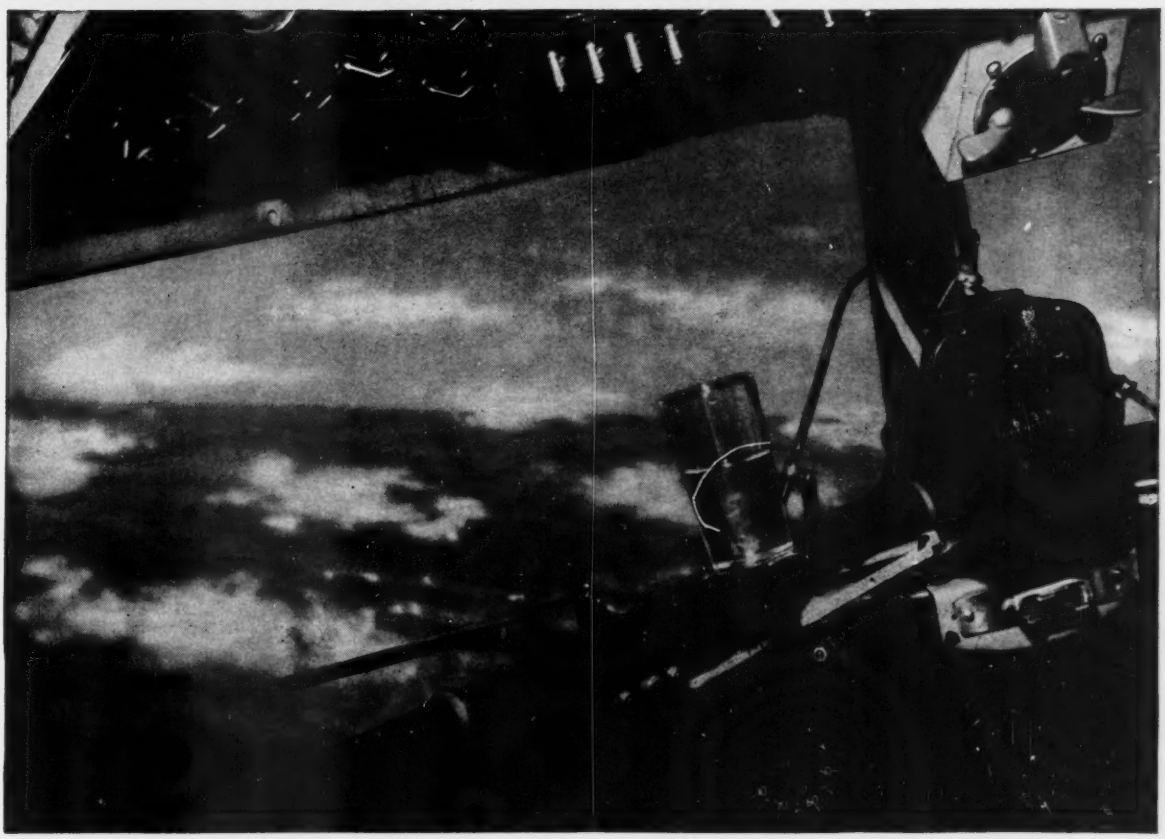
There simply can't be any skidding or side-slipping to upset the glass.

This is typical of aircraft performance made possible by controls produced in Minneapolis by Honeywell's expanding Aeronautical Division.

Besides autopilots, Honeywell's list of current aero products includes electronic fuel measurement systems, dozens of different kinds of gyros, actuators and many other controls.

Today, with aircraft and rockets flying even higher and faster, demands for new controls are being met in the new Honeywell aero plant pictured at left. In developing these new controls, the men in our expanding engineering and research sections often must work in the realm of pure science.

There's real opportunity for engineers at Honeywell—for this is the age of Automatic Control. And Honeywell has been the *leader* in controls for more than 60 years!



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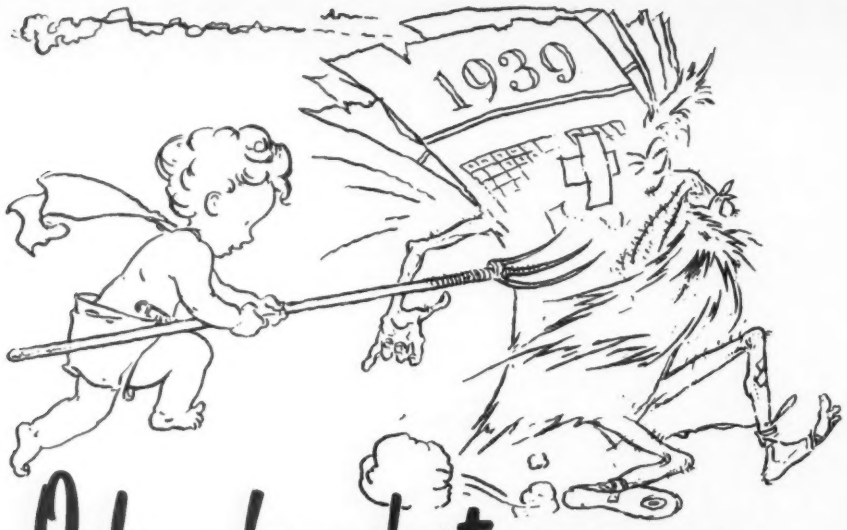
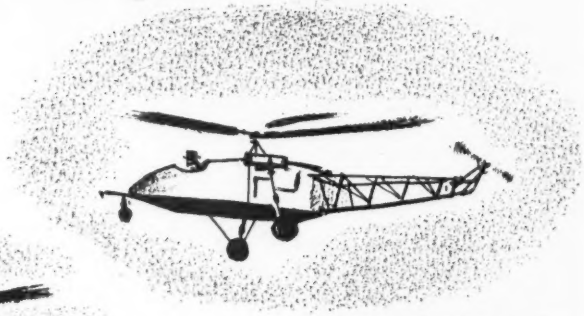


Only a few short years ago

the helicopter was thought to be a "stunt" machine – amazing and amusing, and not particularly important. Events in Korea changed that idea – fast! This fledgling among aircraft performed "impossible" military assignments, spectacularly successful missions of mercy. Helicopters came into their own.



In 1939, the VS-300 with Igor Sikorsky at the controls made the first practical helicopter flight in the United States. Hundreds of later Sikorsky's were delivered for service in World War II.

Now in demand for hundreds of jobs, today's most versatile flying machine is the product of ceaseless testing, highest-calibre engineering, work and imagination.

Future Sikorsky's will be built by tomorrow's engineers. Perhaps *you* belong at Sikorsky where your skill and ability will be continually challenged.

You might find – in Sikorsky Aircraft's research departments, drafting rooms, engineering laboratories – a lifetime opportunity in this young, growing and most interesting field of aviation. Write today to R. C. Banks, Personnel Department.

SIKORSKY

Sikorsky Aircraft, one of the four divisions of United Aircraft Corporation, South Avenue, Bridgeport 1, Conn.

the professors and their freedom

By Thomas Dorgan

Clerk, Superior Court for Civil Business, Suffolk County. Member of the Mass. Legislature, 1933, 1934, 1935 and 1936. Legislative Agent for the City of Boston 1937 to 1940. Clerk in the Superior Court for Civil Business, Suffolk County for 13 years.

I am an American. Not by accident of birth but by deliberate choice I sought and was happy to obtain my American citizenship.

I love America, the land and the people. I deeply cherish the framework of Her laws, so wisely designed to enable her citizens to live in peace and freedom.

The spirit of America wells up strongly from the Declaration of Independence. Breathing forth an intense love for freedom that immortal document anchors the liberty of every American to a sacred Power above the State. It is not the State but God Who has endowed each American with unalienable rights to life, liberty and the pursuit of happiness. The source of an American's freedom is legally recognized as being above the law of the land.

But if the *right* to liberty is above the law, it is made no less clear in the American system that the *exercise* of the right is under the law. The mere right to liberty remains insecure unless assisted by organized society. Men establish governments to insure their God-given rights.

No man can enjoy his freedom when placed at the mercy of a mob. No government is secure when the people become rebellious. A people's freedom is insecure when governed by tyranny. Therefore, wise men create good governments to establish justice, check license, and insure the blessings of liberty to all. Thus Americans in ratifying the Constitution, place the exercise of their rights to liberty *under* the law. Rightly then, should our Supreme Court remark in its decision in a case of United States vs. Lee, 106, U. S. 196:

> "No man in this country is so high that he is above the law. All the officers of the Government, from the highest to the lowest, are creatures of the law, and are bound to obey it . . ."

In a magnificent system of checks and balances, the Constitutional law of the land restrains the government from tyrannizing over the lives of the people, protects the liberty of each citizen against the irresponsible license of his neighbor, and insures the people's government sufficient liberty of action to maintain the existence of the Nation while promoting the general welfare.

Real Americans are always keenly interested in maintaining their legally recognized liberties, especially liberty of conscience, and freedom of religion; liberty to assemble freely, to engage in free speech and operate a free press; the right to due process of law, judicial proof and trial by jury when accused of a crime; their right to protect themselves against legal browbeating by invoking the Fifth Amendment when a statement of theirs will be construed as self-incriminatory.

When it comes to relationship of citizen to citizen and each group respecting the liberties of every other group, matters are usually detailed and clearly specified by local ordinances and State statutes but always with the provision that the laws of each State and each municipality shall be in agreement with Constitutional Law for

> "No State shall make or enforce any law which shall abridge the privileges or immunities of citizens of the United States . . ."

But the founding Fathers were not simply interested in protecting and insuring the individual liberties of the people. They also had very much at heart, the continued existence of a wonderful society of free people which they were about to create. They took great pains to equip the National Government with legal power to protect the Nation against the exaggerated liberties of private groups and the untrammeled license of wayward citizens. Therefore, in the very first Article of the Constitution, Section 8, paragraph 18, it was stipulated that the Government, which had received its delegated power from the consent of the governed, would henceforth be able,

> "to make all laws which shall be

> necessary and proper for carrying into execution the foregoing powers, and all other powers vested by this Constitution in the Government of the United States, or in any department or officer thereof."

This wise provision looked forward to the time when circumstances would change and threats to the national welfare or even national existence would arise from within or without and old laws would have to be amended or new laws established to insure the safety of our national existence as a free people on the face of the earth. The government of the people is their most powerful instrument for promoting the general welfare of all. It is the pledge of their liberties, the protection of their rights. their mightiest power of self-preservation. Rightly, do the people look to the government to protect their existence as a Nation.

In our day, we, the people of the United States are confronted with a grave threat to our National existence. A sinister and ruthless foreign power threatens our national liberty more critically than ever before in history. I will not labor the point of the atrocious contempt for human liberty and man's dignity that has signalized the horrible advance of the Communist Soviet State, as it has sprawled its unholy influence over the face of the earth, bringing under its political jurisdiction, one-third of the peoples of the earth and nearly as much of the land surface of the globe.

By a process, almost too fantastic to believe, this vast conquest has been accomplished with little more political force than occasional police action. By supervision, by political intrigue, by propaganda and the control of the organs of public opinion, the Communists have managed to achieve this stupendous feat of political domination.

While the free world shudders and wonders how they did it, and the enslaved peoples behind the Iron Curtain bitterly regret their indifference that allowed them to do it, here in America the same subtle, poisonous, unholy, Anti-American influence has been going on for many years. In this brief article, I make no pretense of tracing its insidious influence into the social institutions of America. For those who are not blind, that influence stands baldly revealed in the field of Government and labor; in the organs of public opinion, the press and radio; in entertainment and the field of education.

I am here concerned simply with the dangerous menace that has struck America from the field of education. In our schools and colleges and universities the threat of Communism has spread its odor and the attempt of the people's Government to deal with its subversive influence has elicited a most astounding reaction from many men who pride themselves upon being American.

We expect the Communist to double-talk and shout opprobrium upon the Governmental officials who attempt to smoke them out, to expose them and drive them out of circulation. That is to be expected. What was not to be expected was that certain professors and teachers, moulders of the mind of the Nation, should often have obstructed attempts of the people's Government to protect its very existence. Apparently blind to the national welfare and the constitutional right of people's Government to have its own liberty of action in defending itself, they have placed the spotlight of their full attention upon the liberties of the individual and in the name of Academic freedom, have shouted themselves hoarse in defiance of investigating committees, judicial processes and public opinion. The Nation has a right to exist. The people as a whole have their constitutional right to liberty. They have a right to protect themselves. But this type of "freedom-loving" professor, often unwittingly, can see only the badgered individual victimized by suspicious, browbeating politicians.

The State Department could set loyalty to Party above loyalty to Country at times and they were silent. The judicial processes of Government could bog down while countless suspects hid behind the Fifth Amendment and they applauded the protection of the individual. When the resourcefulness of the American people developed the technique of the Congressional Investigating Committee, they howled and shouted that innocent men were being mercilessly pillaried and Academic Freedom was being violated.

As for Academic Freedom, let it be ever remembered that political authority does not create truth. The tactics of the ideologists have no place in America. American citizens must be free to discover and to impart truth. The mind of man must be free to investigate nature, the structure of reality, the meaning of the universe in which he lives. He must be free to report his findings to his fellowmen. If an autocratic politician threatens this precious freedom, the professors must rightly resent his tyrannical intrusion.

But like every other freedom, Academic Freedom likewise remains under the law. If some citizens abuse their right to free speech, to liberty of conscience and freedom of the press, to advocate the violent overthrow of the people's Government, when they conspire to meet and propagandize to sell out the Nation to an insidious international power, when they advocate the dissolution of the very foundations of human freedom, then what real American will be so academically stupid as to imagine that in the name of Academic Freedom all this must be permitted? As Whittaker Chambers pointed out, such notions of freedom are neither academic nor representative of freedom. There is no freedom for it is a system of slavery as the world behind the Iron Curtain attests. It is not academic, for it is dealing with an actual, historical well-organized, ruthlessly conducted international conspiracy.

Has the Government of the people the right, the liberty to deal effectively with such a threat? Real Americans say an emphatic "yes". Academic professors hem and haw and are forgetful of the Nation's right to exist, argue for the freedom of the individual.

It is a position I will not accept. Traditionally, American jurisprudence has defended the right of individuals to say what they want. It has also insisted they assume responsibility for their words. Libel laws punish libelous speech. Public decency laws forbid the sale of filthy "literature" and the display of lascivious shows. Treason is

punishable by death. As for times of peace, the Smith Act determines that speech advocating the violent overthrow of the Government is punishable by law. Freedom must not become license.

It was the people of the United States who ordained and established the Constitution, "in order to form a more perfect union, establish justice . . . and promote the general welfare . . ." It was the people of the United States who delegated their powers to Congress to make what legislation was necessary to maintain and promote the kind of free society they wished. It is the people's Government which has placed the exercise of the rights of each citizen under the law.

Each citizen and each group comes under the law of the land. The liberty of each citizen and of each group is guaranteed by the law of the land. The license of each citizen and each group is checked by the law of the land.

In the interests of the common welfare, the law of the land, through its various States, grants legal charter to educational institutions. In granting such right to legal existence, the purpose of the educational institutions in serving the common welfare is stipulated by legal provision. For example, in the General Laws of the Commonwealth of Massachusetts, it is stated in granting a Charter to Harvard University, that in view of the educational benefits of that institution redounding to the honor of God, fitting the citizens for public employments both in Church and State, to the great benefit of the State, it is declared, "that the President and Fellows of Harvard College in their corporate capacity and their successors in that capacity . . . shall have . . . exercise and enjoy all the powers, liberties and privileges . . . which they now have . . . exercise and enjoy . . ."

As for teachers in the public schools in the Commonwealth of Massachusetts, it is stipulated in Chapter 71, section 30 that

> "the President, professors and tutors of the Unviersity at Cambridge and of the several colleges, all preceptors and teachers of academic and all other instructors of youth, shall exert their best endeavors to impress upon the minds of children and youth committed to their care, and instruction the principles of piety and justice and a sacred regard for truth, love of their country, humanity and universal benevolence, sobriety, industry and frugality, chastity, moderation and temperance, and those other virtues which are the ornament of human society and the basis upon which a republican constitution is founded; and they shall endeavor to lead their pupils . . . into a clear understanding of the tendency of the above-mentioned virtues, to preserve and perfect a republican constitution and secure the blessings of liberty as well as to promote their future happiness . . ."

It was concern for the American Idea of Freedom and in keeping with the basic laws of the

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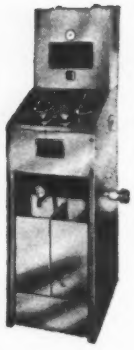

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Commonwealth of Massachusetts, that I sponsored the Teachers' Oath Law that was passed by the Legislature in 1935. Ordinarily it would be an insult to an American citizen to ask him to give his solemn oath professing his American loyalty but these are not ordinary times in which we live. The record of the Communist conspiracy stands so clearly that all who run may read. The

Apart from the volumes of testimony accumulated by the various security agencies and investigating committees of the United States Government, concerning the Communist conspiracy in America, the unanimous report recently issued by the Senate Internal Security Committee, alone is amply sufficient to give each real American cause for keenest anxiety about our national existence. The time has come for loyal Americans to stand up and be counted. We must depend on citizens who are proud of their American citizenship and who treasure the American tradition. Because of these extraordinary times, I thought it not too much to expect a teacher, entrusted with the mind of our youth, to be asked to solemnly affirm his loyalty to the Constitution. Moreover, by a Legislative Act of 1948, the lawmakers of the Commonwealth of Massachusetts increasingly concerned by the spread of the Communist influence, deemed it necessary to put teeth in the Teachers' Oath law to the effect that:

> "Whoever violates such oath or affirmation so far as it relates to the Constitution of the United States and the Constitution of the Commonwealth shall be punished by a fine of not more than $1,000."

In 1951 on the continuance of the Communist threat, I again sponsored a Bill with Repr. Paul A. McCarthy to outlaw the Communist Party in the Commonwealth of Massachusetts, thereby seeking to tighten up the loopholes against the Communist menace. The Bill was passed, thereby making membership in the Party illegal, subject to fine and imprisonment, and further empowering the Attorney General to conduct any necessary investigation in keeping with the purpose of this Act. In the current year, 1953, aroused by the failure of certain colleges and universities to "clean their own house" another Bill (1820) was presented to the House

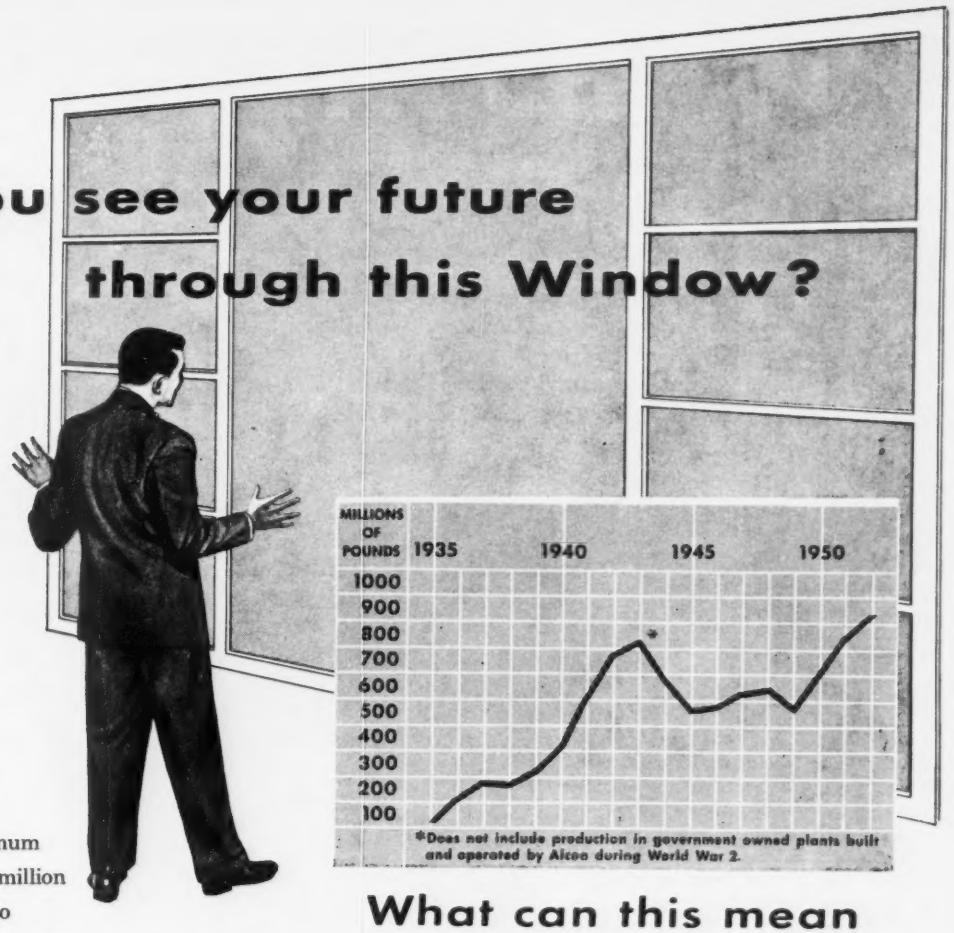
> "instructing the Presidents of the several colleges and the several schools of the Commonwealth of Massachusetts to expel Communists or other persons belonging to the Communists or other subversive organizations, from their teaching staffs after a hearing as guaranteed by the XIV Amendment"

To revert to the main import of my article, I insist that the people of the Nation also must be guaranteed its liberty to protect its national existence. Academic Freedom as well as all our other freedoms is guaranteed only when we live in a free society organized and administered by a free government. The common welfare is vastly more important than the private good, saving principles of truth and justice. It would be ideal if every educational institution would conduct its own affairs in keeping with the admirable purposes for which it was legally Chartered by the Community. The running of the building, the administration of the institution, the hiring of personnel, charting curricula, the work of research and the imparting of knowledge should proceed without political interference. But when all is said and done, the institution should remember that its free existence still operates not above but under the law.

When an educational institution is seriously suspected of harboring within its ranks, treasonable personnel, when on the staff of teachers there are reportedly found individuals who have dedicated their lives to the destruction of the Community, of the liberties of the people as guaranteed by the Constitution, then it becomes a matter of gravest concern to the people's Government. They have a right and they have a duty to check such grave misconduct, to investigate an insidious threat to the common welfare and to take what measures they deem necessary to protect the common good.

Ideally, it would be admirable for each individual and each group to pursue its liberties while refraining from license. When the license of one threatens the liberty of another, the law of the land must be on the side of liberty. No group and no individual is above that law. Academic freedom has its responsibilities as well as its privileges. The professor does not live on an isolated island of his own. He is also a citizen of the Nation, subject to the laws of the land.

Can you see your future through this Window?



This is an aluminum window, one of four million that will go into buildings in 1953. Twenty years ago, it was just an idea in the mind of an Alcoa development engineer. Ten years ago, only a few thousand were made annually. Now, production *is increasing* at the rate of over half a million a year. This is just one of a torrent of new uses for aluminum which means that Alcoa must continue to expand. Consider the opportunities for you if you choose to grow with us.

What can this mean as a career for you?

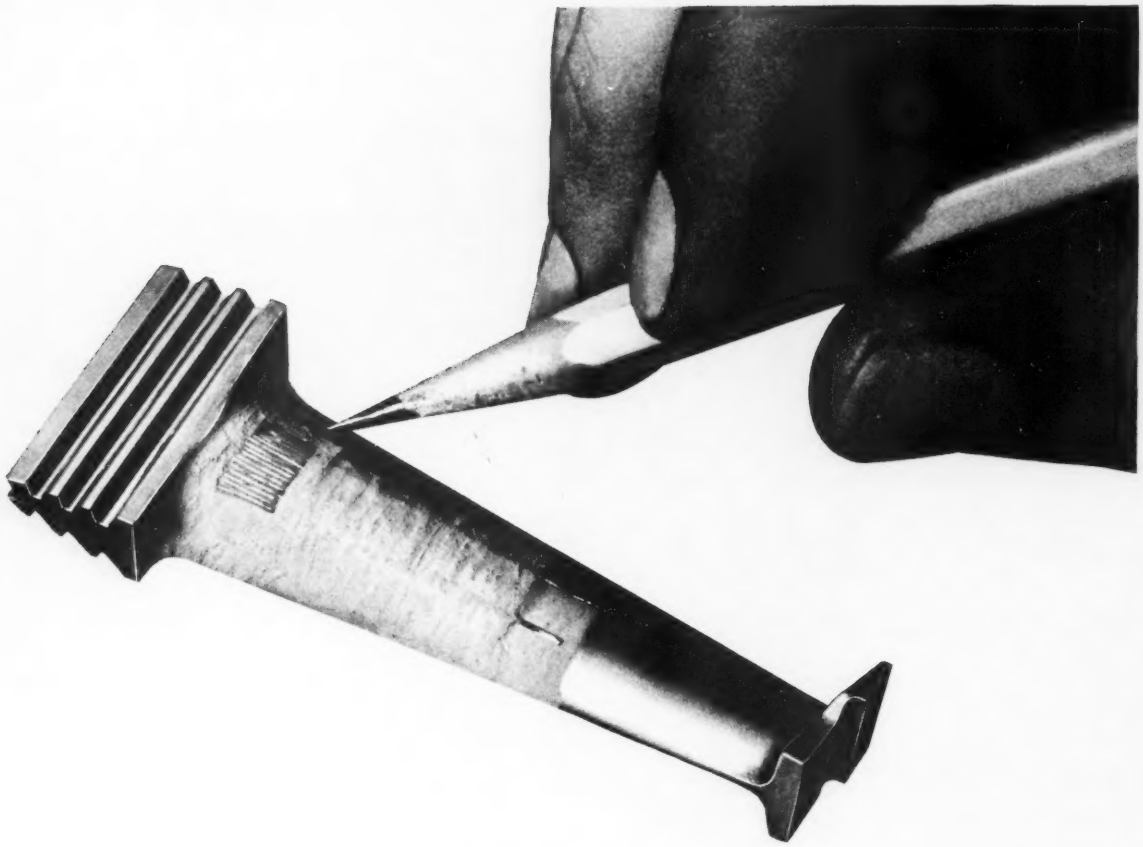
This is a production chart . . . shows the millions of pounds of aluminum produced by Alcoa each year between 1935 and 1952. Good men did good work to create this record. You can work with these same men, learn from them and qualify yourself for continually developing opportunities. And that production curve—is still rising, we're still expanding, and opportunities for young men joining us now are almost limitless.

Ever-expanding Alcoa needs engineers, metallurgists, and technically minded "laymen" for production, research and sales positions. If you graduate soon, if you want to be with a dynamic company that's "going places", get in touch with us. Benefits are many, stability is a matter of proud record, *opportunities are unlimited.*

For more facts, consult your Placement Director. ALUMINUM COMPANY OF AMERICA, Pittsburgh, Penna.

Alcoa Aluminum

ALUMINUM COMPANY OF AMERICA



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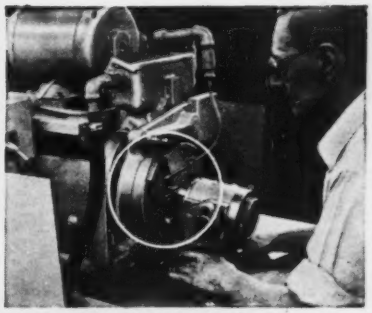

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from the editor's notebook

Open House Rules

Some members of the TEN staff who were around Tech this past summer noticed a wonderfully large number of unattached young women floating around the dormitories. Since it was clearly stated on the dormitory bulletin boards that enforcement of Open House rules this summer was in the hands of the Dean's Office, the credit for this happy state of affairs must be given to Dean Bowditch. We at TEN regard this as proof of the broad-minded attitude of the Dean. The state of affairs this summer ought to convince all students that their interests would be better served if enforcement of Open House rules were placed in the hands of the Dean's Office.

The above bit of whimsy was written by a member of the TEN staff as a suggestion for an editorial. While TEN does not endorse the above opinions, the facts mentioned above are true: there was little or no enforcement of Open House rules this summer. It would be just about physically impossible for the Dean's Office to enforce Open House rules without the co-operation of at least some of the students. The Dean has no more effective and loyal (as well as inexpensive) police force than those dormitory residents who advocate and assist in the rigid enforcement of the Open House rules. With this in mind, the statements of members of student government that enforcement of the rules by students is more lenient than enforcement by the Dean's Office can be dismissed; without the co-operation of the student government there could be no enforcement at all.

On the other hand, it is the position of the Dean's Office that the enforcement of Open House rules is a responsibility which the students should accept. If student government is going to accept this responsibility at all, it should accept it fully and honestly. The often heard statements "I don't like these rules either, but the Dean says they've gottta be enforced, so I enforce them" seem to us to be a dishonest shirking of responsibility. If these students really don't like the Open House rules, or any other rules, let them present a workable alternative; if they cannot think of any alternative, let them enforce the Dean's plan without excuses.

Since the members of the dormitory student government have recently spent a week end educating themselves, at the expense of all the dormitory residents, on the subject of leadership, it may be that in the future we can expect greater acceptance of responsibility among the members of student government.

And More

And are these dormitory politicians who go about beating their drums over Open House rules violations as moral as our society pretends to be? Well, TEN doubts that. In one of the dormitory house committee meetings of this fall, somebody gave a little speech over the necessity of strict observance of the Open House rules and most of those listening shook their heads in approval. Immediately thereafter, the question of the enforcement of the rules against hot plates came to the floor. It turned out that, although hot plates are as illegal in the dormitories as a woman at three in the morning, the rules against them need not be enforced by student government. Why? Is it perhaps because these members of our student government do have hot plates but do not and cannot get women into their rooms?

D. E. and D. F. S.

And Then There Were None

Induced Drag Coefficient of the month goes to the unidentified Army major who, according to the McDonnell plant newspaper, addressed a new group of 150 graduate engineer recruits: "I don't think any more of you young college punks than I would 150 broomsticks." The occasion was the welcome to service of the First Ordnance Guided Missile Support Battalion assigned to the Army's guided missile work at the White Sands Proving Ground, New Mexico. The Army is still trying to get officers and men to stay on and work in scientific jobs in uniform.

From Aviation Week

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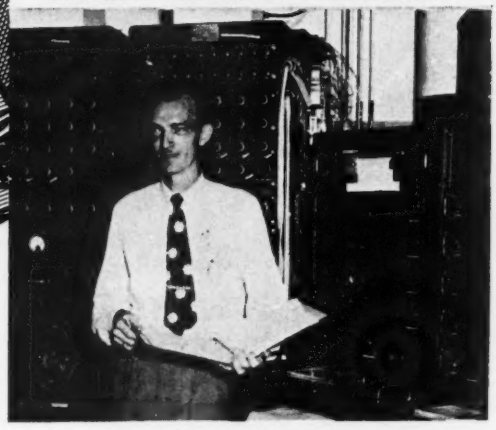

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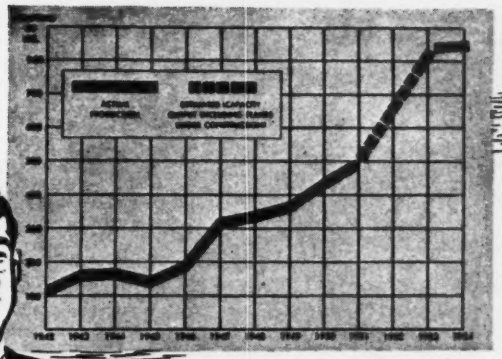

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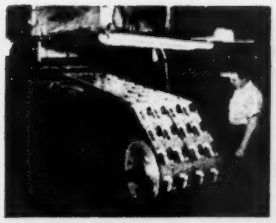

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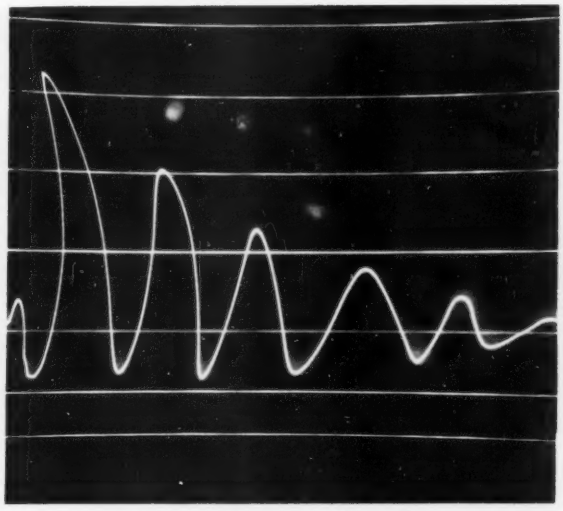
miniature rocket engines

The Potentialities of Certain Rocket Engines Available to Power Small Model Aircraft

By Emmanuel P. Papadakis, '56

The First of Two Articles on Small Rockets and Models Powered by Them.



There is a class of model aircraft propulsion units the use of which has not been explored and exploited to the greatest possible advantage. This class consists of the small reaction propulsion units available—solid fuel rockets typified by the commercial *Jetex* units, and cylinders of liquified gases such as *Sparklets* CO_2 cylinders. The purpose of this article is to investigate the value of these units for propelling small model planes, and to point out some of the advantages and disadvantages associated with their use.

The first of their advantages is their convenience. Supplies for an afternoon's flying can be carried in a coat pocket. Using the above-mentioned units as examples, fuel for twenty flights of the Jetex "50" can easily fit into a pocket. The pellet fuel plus a book of matches and a tiny roll of fuze constitute all the supplies necessary besides the model plane. Except for the inconvenience of the weight, twenty CO_2 cylinders and the fountain-pen sized spring gun needed to puncture can also fit into a pocket.

A second advantage of this type of propulsion unit is its versatility. The same unit will fit into the simplest of mounts on any model built for it. A unit of this class will perform well in any of the three media available to it: on land and water and in the air. Just like any reaction-type motor, however, it is most efficient as well as most spectacular in the air.

A consequence of the convenience and versatility of the units is their low cost, not only in initial outlay but also in cost per flight. The cost of models used with them is also low, varying from twenty-five to seventy-five cents. A more detailed analysis of costs along with other criteria of usefulness is given in Table I.

The above mentioned advantages make this type of propulsion unit excellent for the "Sunday flyer" who wants to build a couple of planes and fly them some sunny afternoon. For the original designer and serious model enthusiast this class of engines poses many new problems, however, and provides a wide-open field for originality and self-expression. Actually very little has been done along the lines of designing models for use with either Jetex or CO_2 power. This new and in several ways superior type of power-plant has been bypassed for other fields found more fruitful in competition. It has also been considered a novelty or child's plaything not really worth investigating. A notable deviation from the last observation can be found in an article written for *Model Airplane News* in the April, 1950 edition. The article showed clearly the applicability of CO_2 power to model planes.

Part of the feeling that this type of power is not useful is engendered by the obvious disadvantages it presents. These disadvantages will be examined shortly. It seems much better to investigate the potentialities of the types of propulsion units under consideration as fully as possible be-

fore deriving any conclusions about their usefulness, than to conclude from the plainly visible disadvantages that they are useless. The problems raised by the disadvantages of these units should be taken as challenges rather than as insuperable barriers to progress.

As you will see from Table I, Jetex has one primary disadvantage while CO_2 cylinders have two others. Jetex, being a solid fuel rocket whose power run is measured in seconds, operates at a high temperature. This temperature is high enough to ignite the materials used in model plane construction. Since this is so, the unit must not be placed in an enclosed mounting. It is easy enough to design a model to meet this requirement, however.

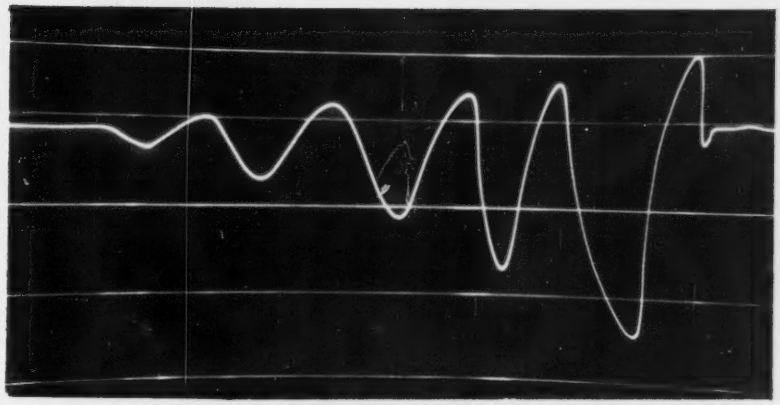


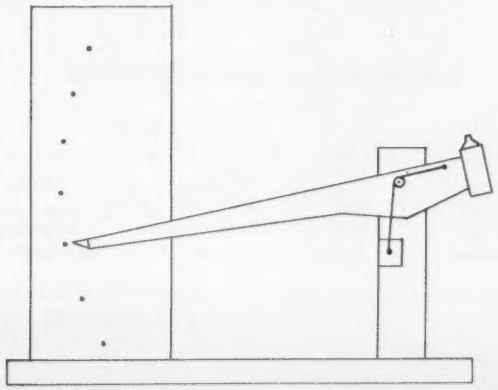
Figure I: Time plot of the motion of the spring balance dynamometer measuring the thrust of one CO_2 Cylinder. Compare this plot with a similar one in the heading of this article to see thedifference in the initial amplitudes of the motion indicating different initial thrusts.

Another complaint heard quite often about the Jetex units is that they are tricky to fire and hence are unreliable in their operation. This is a distinct disadvantage but of course not an insuperable barrier to the building of models.

The two disadvantages of CO_2 cylinders are these: Their excessive weight and their extremely short motor run. An expended cylinder represents a useless mass of twenty-three grams of steel still attached to the model it has propelled. The motor run is effective for from one to five seconds depending upon the size of hole punched in the cylinder cap. These two characteristics of the cylinders pose interesting problems for the plane designer.

The CO_2 cylinders contain approximately seven grams of liquid carbon dioxide having a vapor pressure of 442 pounds per square inch at room temperature. When the metal cap on a cylinder is punctured, the liquid boils violently and changes to its gaseous state. However, considering the cylinder as a thermodynamic system, it can be seen that little heat can flow into the system in the short time of the vaporization process so that the heat for vaporizing part of the liquid CO_2 must come from the liquid CO_2 itself. Thus the temperature of the cylinder and its contents drops extremely fast and some solid CO_2 forms to provide the necessary heat of vaporization. Computation of the amount of CO_2 solid formed is beyond the scope and interest of this article. It can be said, however, that after the dry ice is formed it is incapable of adding to the thrust of the cylinder until heat flows into the cylinder from its surroundings. Since this is so, the CO_2 solid adds to the useless weight of the cylinder and provides only a little thrust.

Figure II: The spring balance dynamometer for measuring the thrust of CO_2 cylinders and other small rockets.



As in all rockets, the reaction to the transfer of momentum rearward out the nozzle (i.e., the hole punched in the cylinder cap) provides the force to propel the cylinder and model. In mathematical terms this is represented by

$$V_e \frac{dm}{dt} = M \frac{dv}{dt}$$

neglecting the aerodynamic forces, where

V_e is the effective exhaust velocity of the rocket gases.

$\frac{dm}{dt}$ is the rate of mass transfer through the nozzle.

M is the mass of the missile being propelled.

$\frac{dv}{dt}$ is the acceleration of the missile.

Then $\frac{dm}{dt} = -\frac{dM}{dt}$ since mass is given by the missile to the exhaust gases via the fuel. Then

$$V_e \frac{dm}{dt} = M \frac{dv}{dt} = -V_e \frac{dM}{dt}$$

$$M\,dv = -V_e\,dM$$

$$dv = -V_e \frac{dM}{M}$$

$$\int_0^t dv = -V_e \int_{M_o}^{M_t} \frac{dM}{M}$$

$$V_t = -V_e \ln \frac{M_t}{M_o}$$

$$V_t = V_e \ln \frac{M_o}{M_t}$$

so that the velocity V_t of the missile at time t at the end of the motor run is equal to the exhaust

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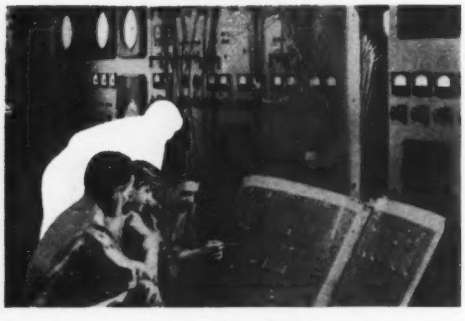

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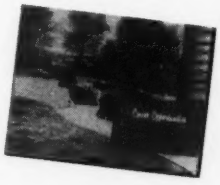

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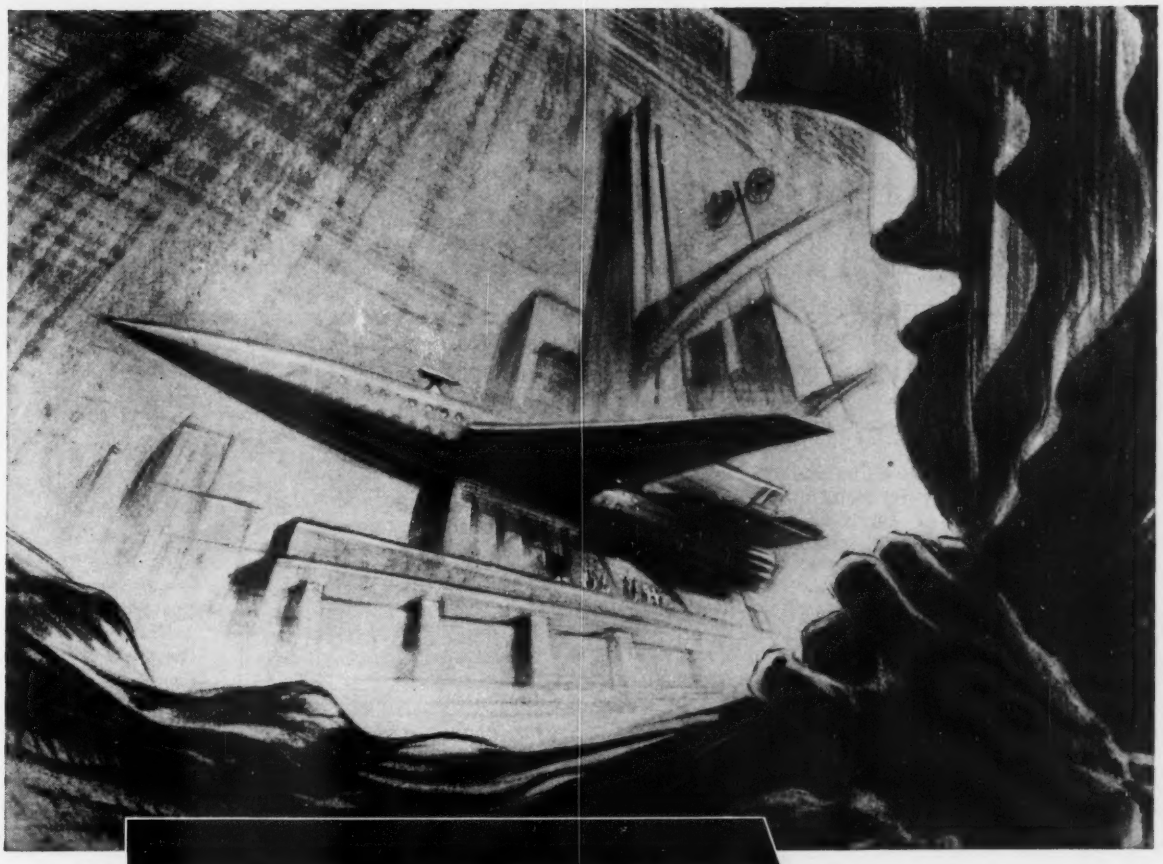

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velocity V_e times the mass-weight ratio of the missile. This equation holds only if V_e is constant and if there are no aerodynamic forces acting upon the missile. If aerodynamic forces exist the equations become much too complicated to have any meaning in this discussion. In the equation

$$V_e \frac{dm}{dt} = M \frac{dv}{dt}$$

we may assume that $\frac{dm}{dt}$ is proportional to V_e from the continuity principle of elementary fluid dynamics, and then say

Thrust $= T = KV_e^2$,

K depending upon the nozzle area. Then V_e depends upon the pressure in the motor chamber, the mass of the gas molecules, the viscosity of the gas, etc.

For Jetex units the exhaust velocity is reputed to be constant during the period of burning. This is very convenient, for it gives a constant thrust, and a constant thrust makes design of a model quite simple. The size of model the motor can fly, Table I, gives one an idea of the magnitude of the thrust of these units.

Data on the thrust of *Sparklets* CO_2 cylinders is not commercially available, since the cylinders were not designed for use as model airplane propulsion units and since interest in their use has not been great. The author has done some work with a spring-balance dynamometer of his own design to try to find more information about the actual thrust of the cylinder.

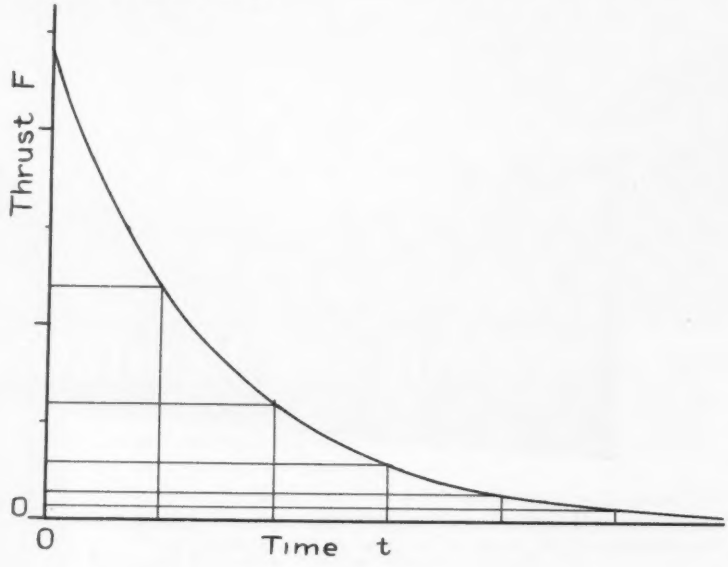
Data from the dynamometer was originally taken by means of a motion picture camera. Later an eight-volt incandescent bulb was mounted on the pointer of the dynamometer and several two volt bulbs were placed on the scale and calibrated. A record of the motion of the pointer on the scale was made by taking a time exposure of this motion in a darkened room with the small lights on. The camera was rotated about the vertical axis of its lens to give a time plot of the motion. The thrust could then be found from this plot. A time scale consisting of a blinking neon bulb circuited to give a consant period was suggested to complete the apparatus. As can be seen from the graph accompanying the article, the motion of the dynamometer pointer is a form of damped harmonic motion.

The general results of the tests on CO_2 cylinders made with this apparatus were as follows:

$$T_{THRUST} = T = T_o e^{-kt}$$

where T_o is the thrust at $t = 0$, t is the time, and k is a constant depending on the area of the nozzle and the units used.

Figure IV: A time plot of the thrust of a CO_2 cylinder showing the half-life characteristic of the thrust.



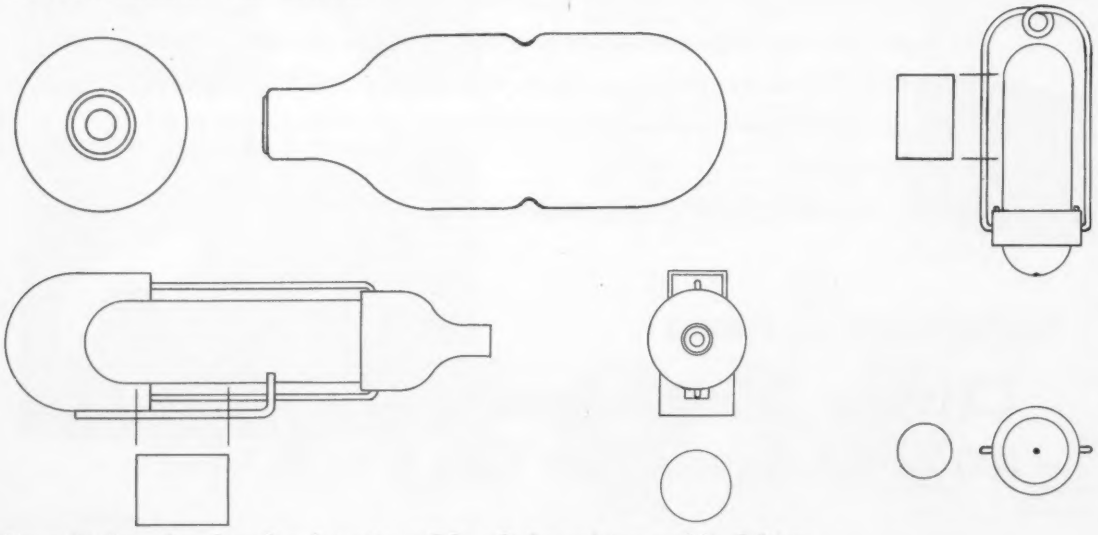


Figure III: Examples of small rocket units: a CO_2 cylinder and two models of Jetex.

TABLE I

Unit	Sparklet CO_2	Jetex 50	Jetex Jetmaster
Type of Unit	Liquified gas	Solid Fuel	
Loaded Weight	30 gm.	7/16 Oz.	33/32 Oz.
Empty Weight	23 gm.	7/32 Oz.	¾ Oz.
Fuel Weight	7 gm.	7/32 Oz.	9/32 Oz.
Mass/Wt. Ratio	1.3	2.0	1.4
Thrust Time	1-5 sec.	15 sec.	13 sec.
Exhaust Velocity	Variable	1200 fpm	1200 fpm
Maximum Thrust	500 gm. plus	½ Oz.	1-¾ Oz.*
Oper. Temp.	—56°C. or lower	Very High	
Recommended Plane size, wing span	8-30"	12-20"	20-36"
Initial Cost, Engine	$0.850**	$1.950	$4.95
Cost per Flight	$0.085	$0.065	$0.10 (?)

*With Induced Flow Adapter the thrust is raised to 2¼ Oz.
**For Spring Gun to puncture the cylinders.

TABLE II

Data on one CO_2 cylinder:	
Weight full, gm.	30
Weight empty, gm.	23
Weight of CO_2, gm.	7
Initial Thrust, gm.	140
Half life, milliseconds	500
Initial acceleration, cylinder plus ten gm. model, Cm./sec.	3442 (=3.5 G)
Mass/Weight Ratio	1.3

The motion of the pointer is given by
Amplitude =

$$A = T_o e^{-kt} - T_o e^{-rt} \cos \omega t$$

where r is a constant dependent upon the damping, and ω is the frequency of oscillation of the pointer dependent upon the moment of inertia of the dynamometer, its spring constant, and the damping.

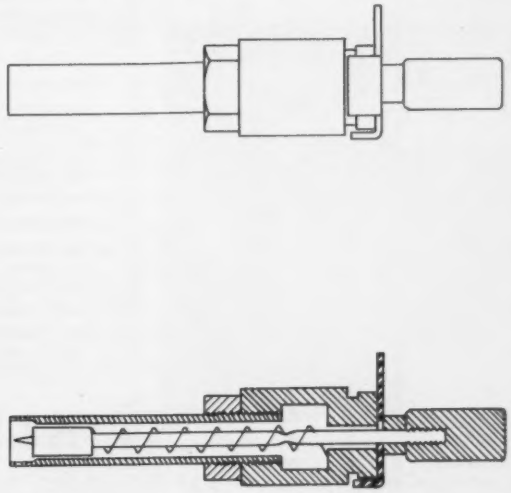
Since the thrust decays exponentially, we may say that it has a half-life, this half-life depending upon T_o and possibly other factors. There is probably some optimum T_o-plus-half-life combination which will give the maximum impulse to the missile carrying the cylinder since the CO_2 gas must behave differently at different velocities, temperatures, pressures, etc. If this combination exists and what it is if it exists is not known. It might be that this combination would not be efficient for propelling model planes anyway.

In practice the half-life of the cylinders varies from fifty to 500 milliseconds. From this fact we see that we need a light, low drag airframe to use this thrust effectively. The plane must also be extremely sturdy to withstand the accelerations and velocities made possible by the use of CO_2 cylinders. Table II shows the initial acceleration on a ten gram model caused by one cylinder set for a relatively low initial thrust to be between three and four G's. This is a considerable amount for any model to withstand, and can lead to quite startling performances.

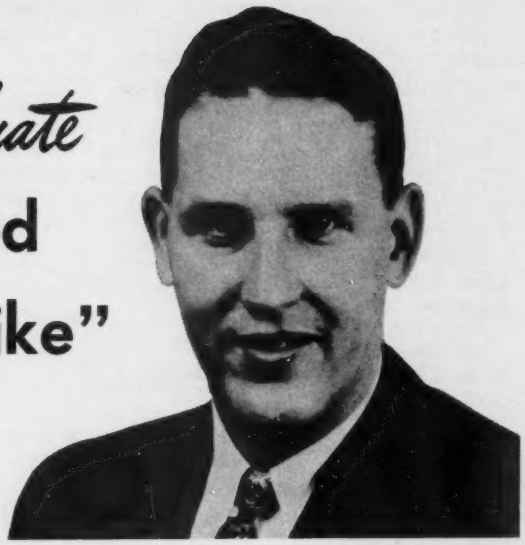
Jetex engines are made in several sizes for versatility. In Table I the characteristics of two of these engines are listed. Both units provide a constant thrust for more than twelve seconds. Most notable from the engineering standpoint is an attachment for the larger of these two models adding to its thrust. The attachment is a tube fitting over the rearward part of the engine and open to the airstream in both front and rear. A flow of air from the atmosphere is induced through the tube by the motion of the gases escaping from the rocket nozzle. Some of the energy of the exhaust gases is transferred to the flowing air, and the thrust is increased. This principle of induced flow in fluid streams has been applied to certain solid fuel rockets made for the armed forces; it is also used in a modified form in the venturi tube vacuum pumps used in chemistry labs. The makers of Jetex claim that the thrust of their unit has been increased by thirty percent by using this device.

It follows from the facts given here that the use of either CO_2 cylinders or Jetex engines presents several problems to the model designer, these problems being quite unlike those encountered in designing other types of models. In an article to be written as a sequel to this one the author will present a summary of the work he has done in designing models for CO_2 power. He will also present some of the problems still outstanding, and some of the work done by others who have made designs for CO_2 and Jetex.

Figure V: Spring needle gun for puncturing CO_2 cylinders.



"Allis-Chalmers Graduate Training Course Helped Me Find the Work I Like"



says HUGH C. SELLS,
Syracuse University, BS—1942
and now Manager, Knoxville District Office

"I guess I was like many graduating engineers. I didn't really know what I wanted to do. When the Allis-Chalmers representative visited the campus, and described their Graduate Training Course, it sounded like the type of postgraduate training I really needed.

"What appealed to me then—and still does—is the broadness of the program. Here is a company filling a unique spot in industry. It makes important, specialized equipment for almost any industry you can name."

Wide Choice of Activity

"It's like a big department store for industry. But that isn't all! In addition, it offers a wide choice of activity within each of these many product groups . . . whether it be sales, design, research or production.

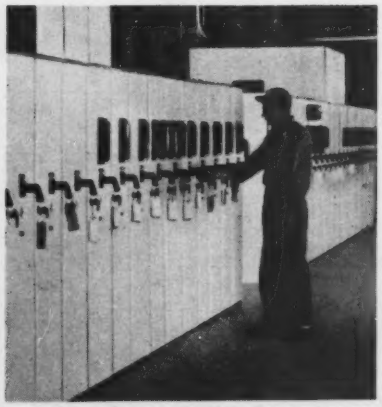
"After getting the broad look at industry the program offers, my interest began centering on Service and Erection of large equipment. This led me into many departments of the company, and I learned about everything from steam turbines to sifters for flour mills."

Valuable Background

"The transition from service to sales was natural. The background of service and erection work proved very valuable.

"So you see, whether you think you know what you want to do or not, the Allis-Chalmers Graduate Training Course is so flexible, so broad in its scope, you have a real chance to find yourself. Best of all, you don't have to waste time doing it."

ELECTRONICS—Modern way to dry sand cores is with Allis-Chalmers *Foundromatic* Sand Core dryer. Revolutionary new process dries cores in minutes instead of hours.



POWER—Neat, compact and safe switchgear installation is big improvement over open framework and knife switches in older installations.

Facts You Should Know About the Allis-Chalmers Graduate Training Course

1. It's well established, having been started in 1904. A large percentage of the management group are graduates of the course.

2. The course offers a maximum of 24 months' training. Length and type of training is individually planned.

3. The graduate engineer may choose the kind of work he wants to do: design, engineering, research, production, sales, erection, service, etc.

4. He may choose the kind of power, processing, specialized equipment or industrial apparatus with which he will work, such as: steam or hydraulic, turbo-generators, circuit breakers, unit substations, transformers, motors, control pumps, kilns, coolers, rod and ball mills, crushers, vibrating screens, rectifiers, induction and dielectric heaters, grain mills, sifters, etc.

5. He will have individual attention and guidance in working out his training program.

6. The program has as its objective the right job for the right man. As he gets experience in different training locations he can alter his course of training to match changing interests.

For information watch for the Allis-Chalmers representative visiting your campus, or call an Allis-Chalmers district office, or write Graduate Training Section, Allis-Chalmers, Milwaukee 1, Wisconsin.

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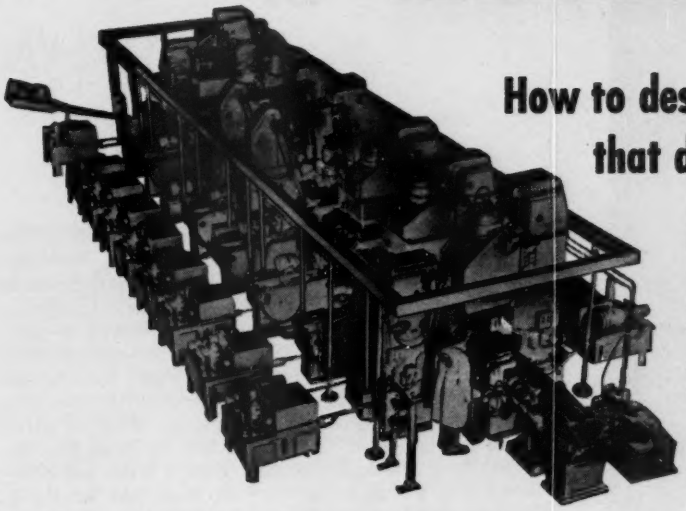
Another page for **YOUR BEARING NOTEBOOK**

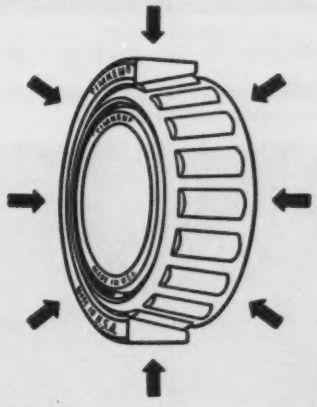


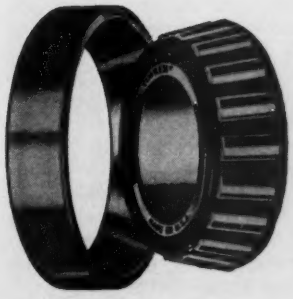
How to design precision into machine that does 98 operations a minute

In designing a machine that performs 98 facing operations every 1.1 minutes, machine tool engineers had to be sure of extreme precision in spindle shafts. Spindles had to be held rigid to eliminate vibration and chatter. Engineers solved this problem by mounting all spindle shafts on Timken® tapered roller bearings.

How TIMKEN® bearings hold spindle rigid

The line contact between rollers and races of Timken bearings gives spindles wide, rigid support. Deflection is minimized and end-play eliminated because the tapered construction of Timken bearings enables them to take radial and thrust loads in any combination. Spindles are held rigid for long-lasting accuracy.





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TAPERED ROLLER BEARINGS

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Many of the engineering problems you'll face after graduation will involve bearing applications. For help in learning more about bearings, write for the 270-page General Information Manual on Timken bearings. And for information about the excellent job opportunities at the Timken Company, write for a copy of "This Is Timken". The Timken Roller Bearing Company, Canton 6, Ohio.

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◐ AND THRUST ⊣◐⊢ LOADS OR ANY COMBINATION ✳

speliology

Exploring

By Rane L. Curl, '51

The stalactites in this New York cave are up to four or five feet in length.

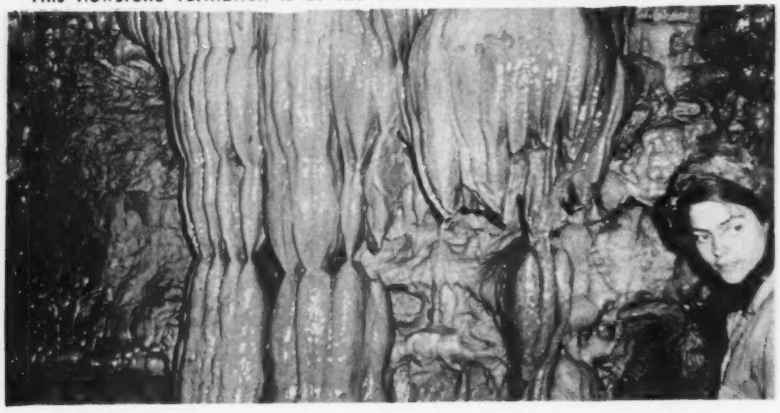
Twelve thousand years ago man came out of the caves to build and live on open ground. For perhaps fifty thousand years before he had lived at the edge of caves for protection and shelter . . . There is nothing to indicate that he cared to trespass far from the light of day into regions even more forbidding and terrifying than the outside world of saber-tooth and mammoth.

Thus man came out of the caves. Now, so many years and so much history later, he is again venturing into his early homes to look with his newly developed scientific eye upon that for which he had no time or desire so long before; perhaps in answer to a hidden attraction which has resided within the mind as a result of so many centuries of accommodation to cave existence.

A spelunker explores the darkness of the Indian Oven Cave of New York before descending into its depths.

Now, however, it is called *speleology*, the science of caves, or *spelunking*, the sport based on the mystery and danger which man forever seeks. Both find their place in the interests of modern man. I intend to describe here some of the attractions which bring men again into the caves.

We climb mountains, go deep into the sea, and fight across dangerous jungles and deserts; any natural barrier becomes a challenge for man to conquer "because it is there." So it is with caves. Dissolved out of native rock ages before, seemingly endless passages possessing strange forms and ever-present challenges and dangers face the modern subterranean explorer. It is an unmapped world into which the explorer descends when he puts on a hard-hat for safety and a headlamp for illumination, bundles himself in clothing against the constant near freezing temperatures, and takes his first steps away from daylight.



This flowstone formation is at the bottom of Mitchell's Cave.

Caves are found throughout the world. The erasing action of the glacial ice sheets left only relatively small caverns in the contorted strata of northeastern America. In the south and southwest, constant conditions and relative freedom from major geological upheavals left vast,

The last frontier

Chairman, Boston Grotto of the National Speleological Society

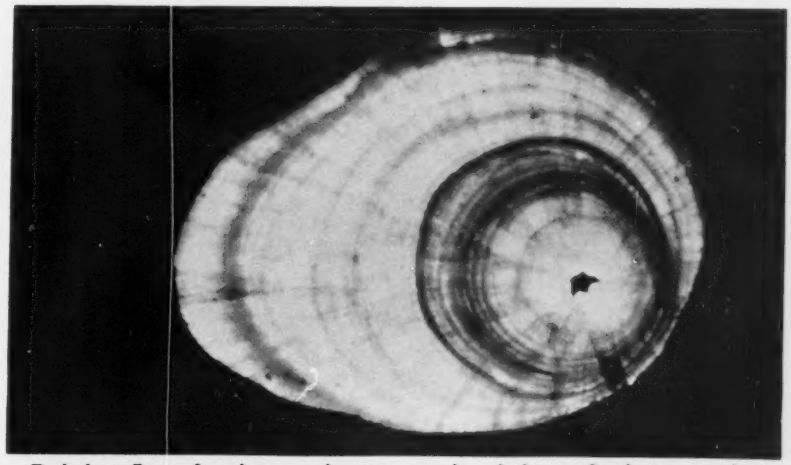
thick beds of limestone in which are found caverns almost "measureless to man" . . . reckoned in hundreds of miles of underground passages and presenting a bewildering maze to the caver.

Starting as slow seepage of ground water far below the water tables in limestone country, dissolving of the rock produced flow channels which surface drainage later followed. With the drainage water came silts and clays which were deposited on the floors of the upward cutting aquifiers; subsequent lowering of the water table allowed the entrance of air . . . and people. Passages are found in every conceivable shape, size, and direction. Some require low crawls in mud and stone, the worst of which is called the "inhale-exhale crawl". Rooms of immense size formed by both roof collapse and solution may measure hundreds of feet in all directions. Strange vertical pits with smooth walls may plummet from the floor of a passage to end in water or in other passages hundreds of feet below. Waterfalls of magnificent height and underground rivers of sombre depth interrupt the paths of exploration. Extensive roof collapse leaves colossal "breakdown" piles through which a passage may be threaded with care.

Nature, however, will not leave the open hole behind, and as soon as air enters the caves, deposition of minerals commences the slow process of refilling the voids. The greatest beauty of caverns comes from the incessant flow of water through cracks, dissolving the native rock with the aid of carbon dioxide in solution and redepositing the limestone from solution by evaporation or loss of the carbonic acid, forming fantastic shapes of rock which seem to have flowed into position in a molten state; hence the name "flowstone". Stalactites hanging from the ceiling drip upon growing stalagmites below. Curtains of travertine hang festooned upon walls, edges of waterfalls and balconies, and wherever water flows. On the floor and in niches in walls, pools of glass-

This sink hole is an entrance to New York's Mitchell Cave, which has a maximum depth of 250 feet.

The Cross section of this stalactite has a mean diameter of approximately one and a half inches.



Turbulent flow of underground waters produced the roof solution pendants of Twin Lakes Cave, Connecticut.

NO. 4 IN A SERIES

The Importance of

Coverings and Sheaths for

THE TERM "COVERINGS", as applied to insulated electrical wires and cables, refers to a relatively continuous homogenous layer or layers of impervious and inert material, applied over an insulated conductor or conductor assembly for the purpose of protecting such conductors from moisture, chemical attack and mechanical damage. Coverings may be colored to indicate circuit identification. Chemical attack refers to damage to the insulation resulting from acid, alkalies and other chemicals in the atmosphere or the ducts or soil in which the cables may be installed. Mechanical damage may result from the abraiding, compressing, cutting and tearing forces to which the insulation may be subjected during installation and service.

Coverings may be made of metallic or non-metallic materials. Metallic coverings may be, (1) a continuous metal tube over the insulated conductor, usually made of lead and known as a lead sheath, (2) metal tapes applied spirally about the insulated conductor and referred to as an armor or a shield, depending on the purpose for which it is used, or, (3) metal wires applied spirally either in one direction or in the form of a braid, and again known as an armor or a shield. Armor is a covering applied primarily for mechanical protection or to add strength while a shield is applied to protect the insulation from electrical stresses or for safety purposes. Non-metallic coverings may consist of, (1) a continuous layer of vulcanized rubber or rubber-like material, generally neoprene, or a thermoplastic material, called a jacket, (2) spirally applied, moisture-resistant fibrous yarn, usually cotton or jute, (3) moisture-resistant fibrous tapes, or, (4) moisture-resistant fibrous braids. Combinations of one or more of these may be used as explained later.

The kind and number of coverings used is determined largely by the size of the conductor or cable, the type of insulation on the conductor and the installation conditions. The following is a brief outline of the types of coverings required for the more important types of insulations and installation conditions.

INSTALLATION in DRY CONDUITS and DUCTS

Single-conductor rubber and varnished-cambric insulated cables require a covering over the insulation consisting of a moisture-resistant cotton braid on the small sizes and a double braid or tape and braid on the large sizes for protection against mechanical damage. On 600 volt cables for installation in buildings this covering must be flame-resistant, and is usually colored for circuit identification. A thin layer of neoprene may replace such fibrous coverings on rubber-insulated cables. Paper-insulated cables require a lead sheath for retention of the impregnant and for mechanical protection. Single-conductor polyvinyl chloride insulated cables usually require no coverings since they are generally considered resistant to flame and chemical and mechanical damage.

Multiple-conductor cables which consist of two or more single conductors assembled as a unit are protected by an outer covering. The individual conductors of multiple-conductor rubber insulated cables are generally protected by a single fibrous covering. The outer covering of multiple-conductor cables usually consists of a tape and moisture-resistant cotton braid on rubber and varnished-cambric insulated cables. A neoprene jacket may replace the outer braid on rubber-insulated cables. A polyvinyl chloride jacket is generally used on polyvinyl chloride insulated multiple-conductor cables. Multiple-conductor paper-insulated cables have a lead sheath over the assembled insulated conductors.

INSTALLATION in WET CONDUITS and DUCTS

The coverings described for use in dry locations on both single- and multiple-conductor cables are suitable for use in wet locations except that a lead sheath is required over varnished cambric and non-moisture-resistant rubber and polyvinyl chloride insulations.

Moisture-resistant rubber insulation requires mechanical protection in the form of a fibrous covering or coverings or a neoprene jacket. A neoprene jacket is preferred because of its greater resistance to deterioration in wet locations. Moisture-resistant polyvinyl chloride may be

UNITED STATES RUBBER COMPANY

insulated wires and cables

used without a covering on single-conductor cables.

AERIAL INSTALLATIONS

The types of coverings described for use in wet locations are generally suitable for aerial installations but greater thicknesses of non-metallic coverings, particularly for single-conductor cables, are required. Fibrous coverings for aerial use are usually made of moisture-resistant jute, sisal or loom-woven cotton of large size. Neoprene jackets on single-conductor cables for aerial installations are about 50 per cent greater in thickness than those used for duct installations. These thicker covers provide the additional mechanical protection required for aerial installations. Neoprene jackets are generally preferred over fibrous or rubber jackets because of their greater resistance to weathering. Lead-sheathed cables with the same sheath thickness as used for duct installations are suitable for aerial installations. A lead alloy containing small amounts of antimony or tin is used instead of pure lead to reduce failures due to crystallization.

DIRECT BURIAL

For direct-burial installations, rubber, rubber-like or thermoplastic jackets and lead sheaths are generally used. The jacket or sheath thicknesses are the same as those used for aerial installations. Lead sheaths require protection against mechanical damage. This usually consists of two servings of moisture-resistant jute yarn immediately over the lead followed by two steel tapes over which are applied two servings of moisture-resistant jute.

SUBMARINE and VERTICAL CABLES

Submarine cables require protection against mechanical damage and additional strength over that provided by the conductors to prevent them from being broken by dragging anchors or other objects. Vertical cables frequently require greater strength for their support than that provided by the conductors. This additional strength and mechanical protection is usually provided by a serving of steel wires which completely covers the surface of the cable. This is known as a wire armor. A bedding consisting of two moisture-resistant jute servings is provided between the non-metallic jacket or lead sheath and the armor wires.

PORTABLE INSTALLATIONS

Cables for portable installations such as those used on dredges, shovels and mining equipment must be flexible and their sheaths must be resistant to abrasion, cutting and tearing. Tough wear-and-weather-resistant rubber or rubber-like jackets are therefore used. Such jackets are generally made in two layers with a reinforcing braid of high-strength cotton yarn between them. The jacket thicknesses for such cables are generally greater for a given size of cable than those of cables for non-portable installations.

SHIELDING

Shields consist of one or more conducting layers on insulated electric power cables, the purpose of which is to confine the dielectric field to the insulation on the individual conductors. The two most important functions of shields are, (1) to protect the insulation against harmful electrical stresses and discharges at its surfaces, and, (2) to reduce hazards of shock.

Since harmful electrical stresses can occur at both the internal and external surfaces of an insulation, particularly on stranded conductors, at high voltages, it is necessary to provide shields at both surfaces. Internal shielding in the form of a semi-conducting fibrous material is generally used immediately over the conductor for operating voltages above 2000. External shielding usually consists of a semi-conducting fibrous layer immediately over the insulation over which is applied a layer of metallic material. External shields are generally used at voltages above 3000 for non-metallic jacket cables and above 10,000 for lead-sheathed cables.

Metallic shields are made of non-magnetic materials such as aluminum or copper and are applied as tapes on cables for non-portable installations and as braids for portable cables. External shields must be grounded at all joints and terminals.

For reprints of these pages write to address below.

Electrical Wire and Cable Department
Rockefeller Center • New York 20, N.Y.

Author rappels down Cat Hole Cave, Massachusetts.

like water slowly build up their own dams by deposition of calcite around their rims. All these are present in shapes that stimulate the imagination.

In 1940 a group of people who like to explore these underground mysteries formed a group which they called the National Speleological Society and chartered it in the District of Columbia.

Spelunker perches above subterranean pool of water.

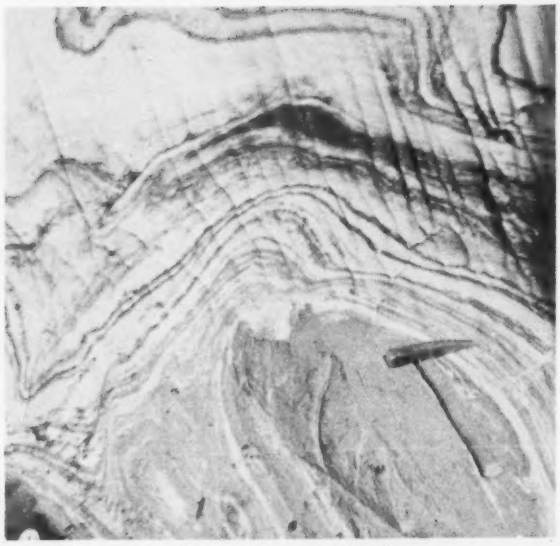


Photo shows an underground natural bridge.

Originally flat lying limestones have been contorted to a banded marble in Eldon's Cave, Massachusetts.

Today this society receives the world's accumulation of stories of adventure below ground, as well as the scientific output of men of geology, biology, bio-ecology, minerology, and many other fields where caves offer opportunity for unusual, useful, and interesting research.

This research extends from government surveys investigating the possibility of using caves

Spelunker approaches cave exit after a tiring outing.

for strategic storage, to more esoteric papers concerning the eggs of *typhlotriton spaleaus* (a cave salamander). Scientific work underground is conducted by the members of many universities and private individuals, and reported in the publications of the NSS. Caves can supply answers to many problems: bat behavior and population studies; hydrologic studies of area drainage; and others.

Boston, as the center of numerous educational institutions interested in such research, and also as the center of great interest in outdoor sports, has the only presently active Grotto (local group of the N.S.S.) in New England. From here, field trips are run to the limestone areas of the Taconic and Berkshire ranges in western Connecticut, Massachusetts, and Vermont, in which are found a large number of caves which are interesting, albeit small compared to southern caverns. To the north, in New Hampshire and Maine; are found unusual rock-fall caves produced by the collapse of the side of a mountain into narrow gorges cut in the native metamorphic schists. These are not true caves, but possess the interest and danger of "breakdown" exploration. Farther to the west the Helderberg Plateau in New York State is the home ground of various other Grottoes of the N.S.S. and is also a focal point for many field trips from Boston, for it is there that deep caves may be found; some up to 250 feet deep with vertical drops of over 100 feet. Extensive underground passages and rivers may yield over a mile of possible travel after entering one of the forbidding shafts.

In all these areas the search for new and bigger holes goes on.

Thus we see that caves, besides supplying an outlet for the curiosity and energies of modern man, also offer a wide field for original work in many allied scientific quests.

It is estimated that there are well over a million miles of underground passages in the United States which may be explored . . . of which to date a scant few hundred have been thoroughly mapped, described, and studied. It is thus not far from the truth to say that here is the "last frontier for the pioneer."

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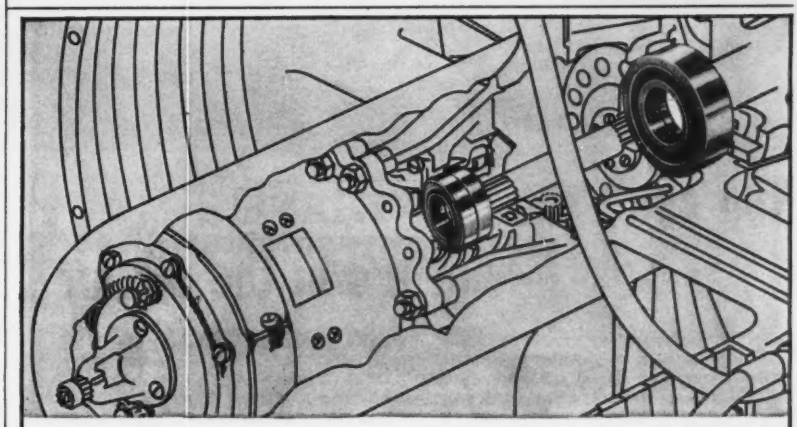

Turning Points in Jet Engine Design

Designing more power into less space . . . a trend in jet engine development . . . puts a premium on space-weight saving factors as well as performance. That's one reason why jet engine designers are specifying more and more Fafnir Ball Bearings for every important turning point from main rotor to accessories and gear boxes. Fafnir Ball Bearings save space and weight as well as meet performance requirements established for the latest type jet engines. By keeping in step with aircraft progress, Fafnir continues to lead in the production of aircraft bearings. The Fafnir Bearing Company, New Britain, Conn.

AVAILABLE

A sound-motion picture depicting high points in the manufacture and use of Fafnir Ball Bearings is available to engineering classes. Write to The Fafnir Bearing Company, New Britain, Conn., for details.

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BALL BEARINGS

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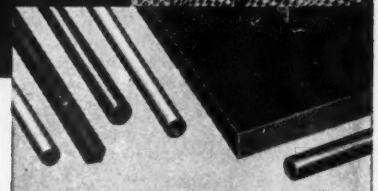
You can't see SYNTHANE but it's in the picture

There are important factors about picture-making you never see in the print—the photographer, the lights, the darkroom, the chemicals. One of many materials essential to photography is Synthane—a laminated plastic.

Synthane is corrosion-resistant . . . Synthane spools carry film from early stages of emulsion coating through developing. Synthane is opaque to infrared rays which accounts for its use as slides for film packs. Synthane is an electrical insulator; you'll find it hidden in flash guns, lighting equipment and projectors. Synthane is wear-resistant and vibration-absorbing, fine for quiet gears in movie cameras.

The photographic industry is only one part of the American industrial picture, and the properties for which Synthane is valued in it are only a few of the many Synthane has. Others are good tensile, compressive, flexural, and impact strengths, dimensional stability, light weight, high dielectric strength, ease of machining. Synthane has all these properties—and more—in combination. And the combination may be valuable to you.

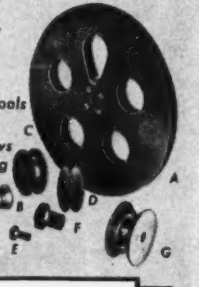
To get the complete picture of Synthane and its possible place in your product, write today for the 24-page Synthane Catalog. Synthane Corporation, 42 River Road, Oaks, Penna.



Here you see the three basic forms of Synthane laminated plastics—sheets, tubes and rods. All three are made by applying heat and high pressure to resin-coated laminations of paper, fabric, glass cloth or mat. Synthane is thermo-setting, has many much-sought properties in combination.

Synthane in Photography

A—16mm Reel
B,C,D—Film processing spools
E,F—Chemical-resistant screws for developing equipment
G—35mm film carrier



Synthane-one of industry's unseen essentials

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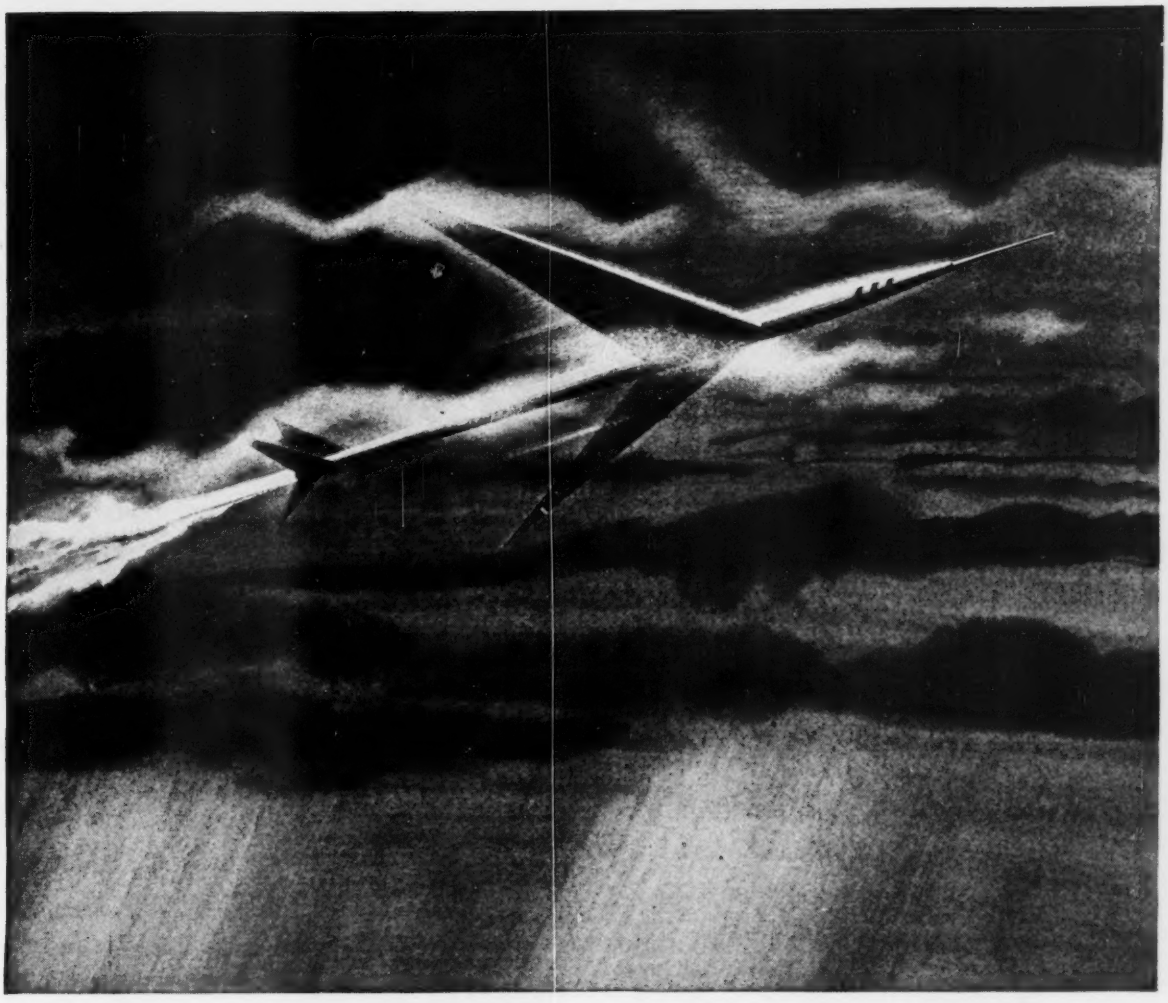
LAMINATED PLASTICS



Do you want to get ahead in engineering?

Then—after you graduate—join a company that's expanding in fields where big engineering futures lie.

At Boeing you'll find plenty of room to get ahead in such projects-with-a-future as a major guided missile program . . . research in supersonic flight and nuclear-powered aircraft . . . America's first-announced jet transport . . . and the revolutionary B-47 and B-52 jet bombers.

You'll find Boeing a stable 37-year-old company, that has grown practically continuously. For example, Boeing now employs 6000 engineers in contrast to 3500 at the peak of World War II. And although Boeing is a large concern, it is so organized that each engineer is an individual who stands out—and progresses—in proportion to his ability.

Boeing is constantly alert to new techniques and materials—and approaches them without limitations. Extensive subcontracting and major procurement programs—directed and controlled by engineers—give you a varied experience and broad contacts with a cross section of American industry. No industry, in fact, matches aviation in offering such a wide range of experience, or breadth of application—from pure research to production design, all going on at once.

Boeing engineering activity is concentrated at Seattle in the Pacific Northwest, and Wichita in the Midwest. These communities offer a wide variety of recreational opportunities. Both are fresh, modern cities with fine residential and shopping districts, and schools of higher learning where you can study for advanced degrees.

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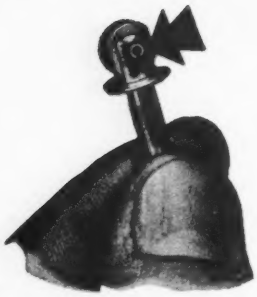
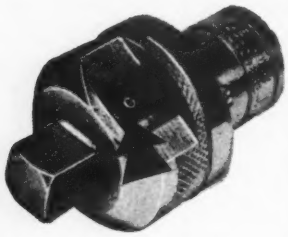
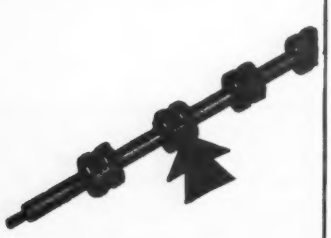


Replacing a rivet

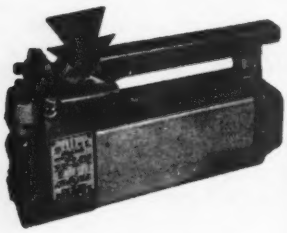
. . . a hinge pin



. . . a stop pin

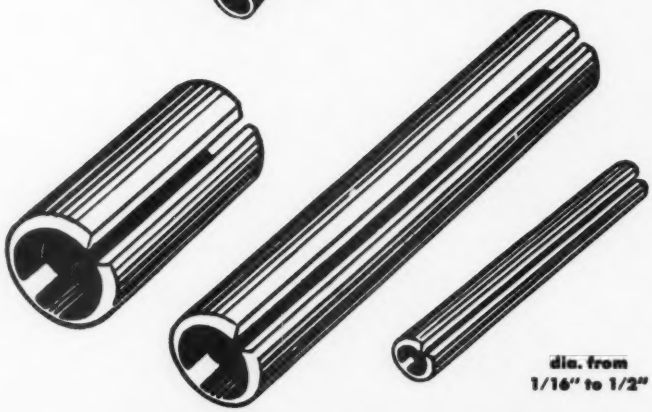


. . . a set screw



. . . a bolt and nut

ROLLPIN



dia. from 1/16" to 1/2"

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the young engineer looks at industrial retirement plans

They Are a Substantial Part of His Total Pay

By Karl E. Sterne, G.

The idea of retirement is so remote to a man just graduating from college that he seldom pays enough attention to the retirement plans that most of his prospective employers offer. He may decide to work for one firm because it will pay him $500 a year more than another, while overlooking the pension plan of the other firm which may well be worth $1,000 annually—not at age sixty-five, but immediately.

Let us take an extreme example: the Army. A married second lieutenant starts out with a monthly salary of $222 plus $133 subsistence and quarters. After 30 years he can retire on three-quarter pay. Let's say he winds up a colonel and is pensioned for 18 years, which is not far from average. The total amount paid to him as pension is no less than sixty-nine per cent of the total active pay he received.[1] Thus if we pro-rate his pension as sixty-nine cents in addition to each dollar of active pay, we discover that his starting pay is not $355 but $600. It's pretty hard to match that with an industrial salary.

Nevertheless the great majority of M. I. T. graduates go into industry, where salaries are higher, years of retirement fewer, and pensions lower—all factors which reduce the ratio of the total pension paid over the years of retirement to the total salary paid during the years of employment. Such a ratio is a convenient index to the actual value of a pension plan, since, as we see above, it shows how much extra salary the pension is equivalent to. Our article will demonstrate how to calculate this figure for any pension plans that you may wish to evaluate.

Before discussing retirement plans, we must take up two factors which determine how much total pension you will receive. These are the salary you may expect to earn (since pensions are usually determined by taking a percentage of salary), and how long you will live. Let us look at them in some detail, since not only the average engineer but sometimes the expert who devises a retirement plan is apt to miscalculate at least the latter factor seriously.

How Much Will Your Salary Be?

Detailed information is available about engineering salaries in the U. S., and just enough data have been collected about salaries of M. I. T. graduates to indicate that they earn considerably more than the U. S. average. One reason is that over forty per cent of M. I. T. men wind up in management positions,[2] with high salaries which are not adequately included in engineering surveys.

Taking 1949-50 figures, we find that the average engineer starts at a salary of about $4,000 a year. For the next twenty years he receives an annual raise of $200, bringing his salary up to

[1] "The World Almanac, 1953", New York World-Telegram Corp., New York, p. 724; 1953. Calculation assumes five years spent in each rank.

[2] P. A. Simmons, "An Investigation of Employment Patterns Being Established by M.I.T. Alumni", M.I.T. M.S. Thesis; 1950.

$8,000. Then his annual raise drops to about $150 for fifteen years, after which his salary levels off and remains at around $10,000 until he retires.[3]

A 1951 study of chemical engineers, who generally attain a higher level of education and pay, shows that they pretty nearly parallel the first twenty years' pay of all engineers, after which their annual raise *increases*, so that they reach a peak of $12-$13,000 at retirement.[4]

The only figures available on Tech men are those compiled in a 1951 survey of Technology Loan Fund recipients.[5] In the absence of other data we must assume that these men are typical of all M. I. T. graduates. (This is not too bad an assumption, since the men are not sufficiently represented in this sample are probably at both ends of the salary range: those with well-to-do fathers whose jobs they may take over, and those considered too poor a risk to merit a loan.)

Salary figures are availale only for the first twenty years after graduation, as the T. L. F. has been in existence only since 1930. We shall make a linear extension of these salaries for another fifteen years before considering them to level off. This is a fairly conservative estimate, since any falling off of engineers' raises after twenty years should be more than offset by the increased raises that can be expected of men entering management.

The T.L.F. survey shows that the median Tech man starts at a salary of about $4,500, and receives an annual raise of $300. Extending this rate of increase for thirty-five years and then leveling it off, we wind up with a salary of $15,000 at retirement. If our Tech man works for forty years before retiring, he will have earned a total of $410,000.

How Long Will You Live?

You have probably run across the statistic that the average life span of a white American male is sixty-seven years. You may also know that you are credited with an extra three and a half years when you safely reach the age of twenty. It is a common error to assume that if you retire at sixty-five, you may thus look forward to only five and a half years of retirement. Many people furthermore believe that since length of life is an inherited characteristic, such averages do not apply to them.

Studies show, however, that if you have exceptionally long-lived (or short-lived) parents, you may expect to live only one or two years (or less) than the average.[6] But the mere fact that you are graduated from an eastern college adds an average of *four years to* your life,[7] and your choice of a technical career gives you another one and a half.[8] And that's not all.

The above average was based on death rates today. For the last hundred years death rates have been falling, and they will undoubtedly continue to fall. Statistically speaking, you will be exposed to the death rates that apply to each age bracket in the year that you reach that age. By the time you turn forty or fifty. lower death rates will prevail, and you may expect to live longer. Although the exact length of time is a matter of considerable controversy, an extra five years is a fairly conservative figure to assign to this factor.[9]

And so, if you retire at sixty-five, you may expect to collect not five and a half but sixteen years of pension—almost three times the amount usually assumed.

Retirement Plans

Now we are ready to examine the retirement plans themselves.[10]

Such a large number of salaried employees are covered by pension plans today that it is surprising to discover that fifteen years ago most of these plans did not exist. A pension used to be considered a gift to reward faithful employees; it was awarded at the option of the management; and an employee could be fired a few years before retirement thus losing all chances of a pension. There was generally no "retirement plan" under which an employee could look forward to a definite pension. No money was set aside for future pensions—they were simply paid out of current earnings, and a number of large firms had to reduce pension payments during the depression years.

Today, although almost all retirement plans are financed soundly, there are still firms which consider pensions as over and above the wages

[3] "Employment, Education and Income of Engineers, 1949-1950", U. S. Department of Labor, Bureau of Labor Statistics, p. 42; 1952. Table has been extrapolated downward.

[4] "Manpower Resources in Chemistry and Chemical Engineering", Bureau of Labor Statistics Bull. 1132, p. 108; 1953.

[5] H. E. Lobdell, "T. L. F. Survey", *The Technology Review*, vol. 54, No. 4; February, 1952.

[6] L. I. Dublin and A. J. Lotka, "Length of Life", Donald Press, New York, p. 117; 1949.

[7] Ibid., p. 219. Actually this study showed graduates of eight Eastern colleges to have a life expectancy at age 22 of five years more than the average. However, the survey covered men who graduated around 1900, when life expectancy was almost 20% lower than it is today, so we have somewhat arbitrarily assumed that the 20% improvement also reduced the margin by 20%, to four years.

[8] J. S. Whitney, "Death Rates by Occupation", National Tuberculosis Association, New York; 1930. Technical engineers have a death rate only 81.5% of that of all professional men between ages 15 and 64. From this it is not difficult to calculate the 1½ year differential.

[9] Since this is the most controversial figure in our paper, we would like to discuss it more fully.

The question of future death rates is a hard one to answer. Demographers are split into two camps. One group, represented by P. K. Whelpton of the U. S. Census Bureau, feels that we have extended the life span almost as much as we can, and it points out that the lowered death rates have been confined to the younger age brackets, while older people have never enjoyed any improvement in life expectancy. This group has prepared projections of life expectancy which have consistently underestimated it, as shown by subsequent experience.

More recently, a group of British demographers such as Peter R. Cox and V. P. A. Derrick has set out to disprove the notion of a fixed life span, and a remarkable lowering of death rates in the upper age brackets during the last ten years has strengthened their theory considerably. Basically, they hold that death rates are lowered not by calendar years but rather by generations, and if a low death rate for people in the 30-40 year age bracket appears in 1950, then a similarly low death rate will appear for the 60-70 year age bracket in 1980, since both statistics are produced by the same group of people.

[10] Much of the following material is taken from R. B. Robbins, "Pension Planning in the United States", Teachers Insurance and Annuity Association of America; 1951; and from, "A Study of Industrial Retirement Plans", Bankers Trust Company, New York; 1953.

due the employee. Quite a number still reserve the right to fire an employee without paying him the money accumulated towards his retirement; in fact there is still some question as to whether the employee has a legal right to this money, even when it is specifically paid into an account kept for him. Retirement plans, in short, are relatively so new that they will undoubtedly be modified considerably in the light of further experience, and you should consider a specific plan more as an indication of the firm's policy on retirement, since by the time you are ready to retire it will probably have changed.

Let us take a look at two of the more forward looking retirement plans to see some desirable features.

The United Nations plan requires all U. N. employees to contribute seven per cent of their salary, with the U. N. contributing fourteen per cent plus any deficit. (Evidently this plan is worth at least twenty-one per cent of the salary.) The employee is retired at age sixty. His pension is calculated at one-sixtieth of the average of his last ten years' pay, times the number of years he has contributed to the plan up to thirty. Thus if he retires after thirty-five years of service, his pension is fifty per cent of his final salary. If he leaves the U. N. before retirement but after at least five years of employment, he receives both his own and the U. N.'s payments in full.

The Carnegie plan, which is used by many U.S. universities, requires a total contribution of from twelve to twenty per cent of the teacher's salary, of which one-half to two-thirds is paid by the college and the rest by the teacher. These payments start at thirty and end at sixty-five with retirement. They purchase an insurance policy calculated to provide an annuity of fifty per cent of the salary received between ages sixty and sixty-five. If the teacher transfers to another school, the policy is also transferred; if he leaves the school system, he may continue to pay on the policy himself; if he dies before reaching sixty-five, the accumulated funds are paid to his beneficiary.

These plans have one advantage which is not frequently found in industrial plans: none of the pension is forfeited if the employee leaves after more than a few years. Since one of the strongest advantages of a pension plan to the employer is that it keeps the employee from changing positions just when he becomes most valuable, most firms prefer to arrange matters so that an employee is penalized part or all of his accumulated pension funds if he leaves before retirement. Since it is likely that you will not spend your life with the first company you work for, this factor of *vesting* (which means making the funds contributed by the firm available to the employee) is an important one to consider, and should preferably take place after a minimum number of years.

We see also that these plans take a realistic view of the value of a pension, and require the employee to contribute a considerable sum himself. In general, most retirement plans which provide more than a nominal pension require the employee to contribute something less than half of

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One of the problems in designing an electronic digital computer for airborne automatic controls is that of storing information used by the system.

Techniques employed in the magnetic drum memory unit of the Hughes airborne digital computer are reviewed by project members Arthur Zukin (left) of the Radar Laboratory, and Dan L. Curtis of the Advanced Electronics Laboratory.

At Hughes, where the airborne electronic digital computer was pioneered, the problem presented by the memory unit was attacked basically by the Hughes technique of systems planning and analysis. This involved an exhaustive examination of the requirements, an evaluation of the best means for satisfying them, and the design of the simplest possible mechanization consistent with superior performance.

A magnetic drum memory unit was chosen as the most compact and rugged storage device for the airborne digital computer. The unit developed by Hughes provides storage space for more than 2500 19-digit words. Density of the magnetic recording is approximately 100 binary digits per inch. Rotating at 8000 rev/min, the 4-inch diameter drum permits computation at a rate of 160,000 binary digits per second.

From an analysis of the logical integration of the memory unit into the computer system, the unique "floating reference" principle was developed. Instead of standard coincidence-type methods for selecting numbers from the magnetic drum storage, a floating reference system is used in which the memory position is determined by counting word times from the *end* of the preceding operation. This technique produces for this application a performance equivalent to a random access memory and results in a substantial saving in equipment.

A major effort at Hughes is also devoted to adapting electronic digital computer techniques to business data processing and related applications – uses unquestionably destined for far-reaching peacetime application.

Activities at Hughes in the computer field are creating some new positions in the Laboratories. Experience in the design and application of electronic digital computers is desirable but not essential. Engineers and physicists with backgrounds of component development or system engineering are invited to apply.

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What's Happening at CRUCIBLE

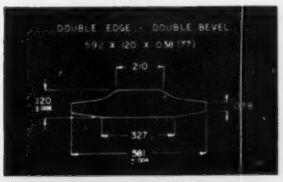
about clicker die steel

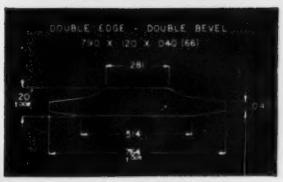
what it is

Clicker die steel is a special cold rolled alloy steel. It is used in making clicker dies for cutting leather, rubber, plastic, felt and fabrics of other compositions that go into the making of shoes and similar products.

Finished clicker die ready for cutting shoe leather.

Some of the clicker die steel standard shapes.





Wider shapes are used when dies are sized by surface grinding after forming and welding. Standard widths are provided when the dies are not to be surface ground.

how it is used

Clicker die steel is furnished to the die maker in either single or double edged form in one of several standard shapes. The die maker first shapes the die by bending the die steel to a pattern that provides the desired configuration, and then welds the two ends at a corner. He finishes the die by grinding a bevel on the outside of the cutting edge and filing the inside edge. Before the finished die is hardened and tempered, the die maker forms identification marks — combinations of circles and squares — in the cutting edge so that the material cut from it may be easily identified as to its size and style.

In the cutting operation, the leather or other material is placed on an oak block in the bed of the clicker machine. Then the die is placed by hand on the material which is cut as the aluminum faced head of the machine presses the die through it. The clicking sound which the head makes as it strikes the die is where the term "clicker machine" derived its name.

what it is composed of

Clicker die steel as produced by the Crucible Steel Company of America is a controlled electric steel in which the combination of carbon and alloy is designed for maximum toughness and proper hardness after heat treatment.

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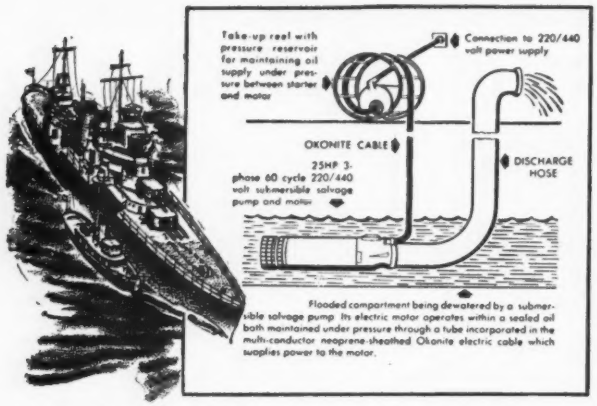
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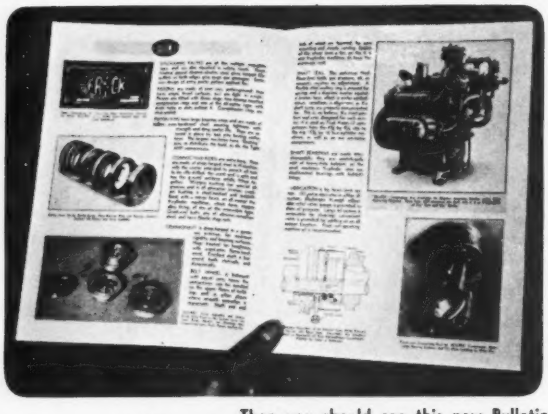

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their expected cost, but not as much in terms of salary as the above plans call for.

The U. N. and Carnegie plans are based on the final salary rather than on the average salary over the whole span of employment. This is preferable because such a pension more accurately reflects the standard of living at the time of retirement, and more and more firms are changing to this form of calculating the retirement pay.

Finally, these plans (especially the Carnegie plan) guarantee the employee adequate retirement pay no matter what. The employer enters into a firm agreement to furnish a fixed pension or its equivalent. Some industrial plans do not legally commit themselves to paying the pension at all. Others credit the employee with a percentage of the company's profit each year; although the money is not paid until the employee leaves the firm, this is not a true retirement plan, since it does not guarantee an adequate pension. Rather it is a fluctuating profit sharing plan, and the employer might better distribute this money at once as the incentive pay which it really is.

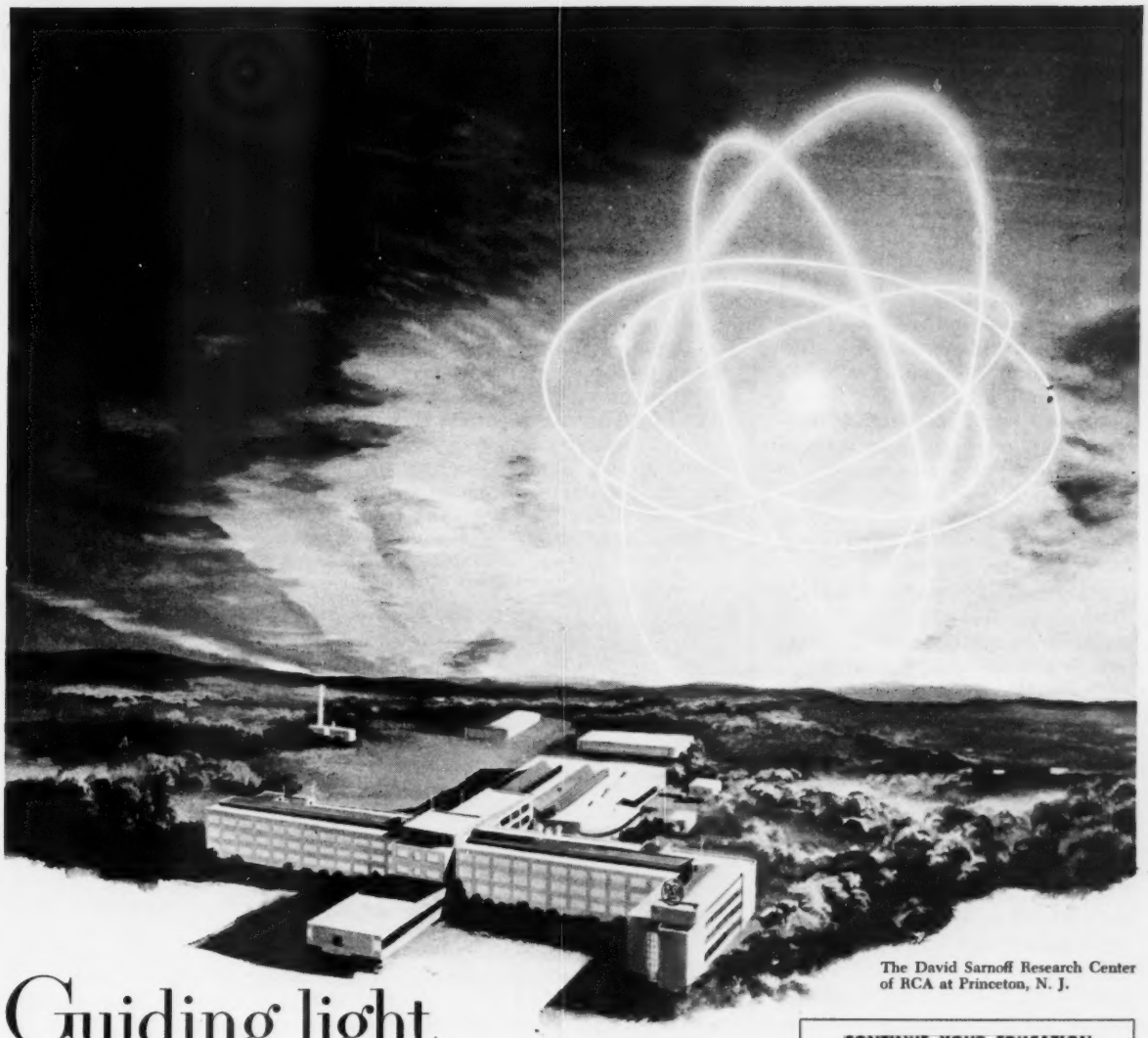
Now with all this behind us, let us examine an average industrial retirement plan, and see what it is worth. The plan we shall describe is a composite of over three hundred pension plans listed by the Bankers Trust Company of New York in "A Study of Industrial Retirement Plans", 1953 edition.

The typical plan requires the employee to pay 4 per cent of his salary into the retirement fund. This money will be returned to the employee any time he leaves, but vesting occurs only after about fifteen years. Retirement pay begins at sixty-five, and is calculated at one and one-quarter per cent of the average salary during the last five years of employment, times the number of years employed.

Remember that our median M. I. T. graduate works for forty years, winding up with a $15,000 salary and total earnings of $410,000. Thus his pension will be fifty per cent of $15,000, or $7,500. He has contributed four per cent of $410,000, or $16,400, and if it has been invested at about four per cent it will be worth $30,000. Since he can expect to live sixteen years, he will collect retirement pay totalling $120,000, of which the company contributes $90,000.

Pro-rating the firm's contribution per dollar of earnings, we arrive at the true value of the pension plan as 90/410 or twenty-two per cent of his salary. Including the retirement plan, then, his starting pay is not $4,500 but $5,500.

Note that this is an average of present-day plans, and there are many which are more generous. Of course, by the time you are ready to retire, the plan will have been altered, and we shall stick our neck out and predict some changes. First of all, vesting will undoubtedly occur much earlier. Second, a part of the pension will probably be payable to your widow if she outlives you, which will extend those sixteen years of pension to well past twenty. Third, the pension funds will be paid to your estate if you die before retiring. And finally, your contribution will undoubtedly be increased once the company discovers that its engineers live considerably longer than is presently expected.



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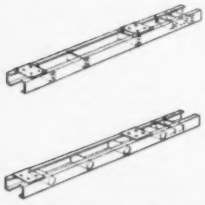
With more and more emphasis being placed on cost of manufacture to meet competition, industry's management today looks to its engineers to initiate money-saving ideas in product designs. As a result, the alert engineering student who can come up with unique money-saving suggestions in his designs will find greater acceptance for his suggestions and a promising future in personal advancement and income.

Often too little attention is devoted to how a product design can be simplified to eliminate costly manufacturing manhours once a basic design is established. To achieve this end, where designers reappraise product details for welded steel construction, production costs are being cut an average of 50% compared with manufacture using castings.

The reasons for the lower cost with welded design are basic . . . lower cost of steel per pound, fewer pounds of steel needed and simpler shop procedures. In addition, steel designs are stronger . . . resist fracture from shock . . . are more modern in appearance.



FORMER BOLTED DESIGN *of base for electric switch. Bases range from 6 to 10 feet long. Are subject to severe cantilever stresses from opening and closing of switch.*

PRESENT WELDED STEEL DESIGN *incorporates tubular cross members. Weight cut 20%. Deflects one fourth as much under load. Costs no more to build.*

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briefing the news

Resistance to Rust Disease

It has been announced that by the use of nuclear particles from the atomic pile at Brookhaven National Laboratory at Upton, New York it has been possible on a laboratory scale to induce disease resistance to oat rust in a single variety of oats which was previously very susceptible to it. However, the strain is not yet available in commercial quantities.

The announcement was made by Dr. Calvin F. Konzak, Brookhaven biologist, at the afternoon session of the American Society of Agronomy. The subject of his talk was "Mutations in Oats Induced by Thermal Neutron Irradiation."

At the agronomy meeting, Dr. Konzak told how in 1952 he exposed several hundred oat seeds of the Mohawk variety to neutrons, the nuclear particles which emerge from uranium atoms as they split in a nuclear reactor. The seeds were lowered through the thick shield surrounding the Brookhaven nuclear reactor, and the nuetrons were allowed to impinge upon them up to eight hours.

The seeds were then planted near Aberdeen, Idaho, where the Mohawk strain thrives, Dr. Konzak explained, thus minimizing any weakness which radiation may have caused in the seeds. Location of the second generation was not a key factor, so when this crop was harvested seeds were shipped for planting at Brookhaven in the summer of 1953.

As they grew Dr. Konzak artificially inoculated the second-generation plants with oat stem rust race 7a, to which the Mohawk strain is particularly susceptible. The rust fungus spread uniformly throughout the oats nursery, affecting all but a few plants. For each of these plants, it was demonstrated that infection had taken place, but that the plant had a resistance which prevented damage.

This fall, seeds from the third generation of the resistant plants were tested in the greenhouse. Resultant plants were inoculated with race 7a, and resistance was demonstrated, confirming the summer's results.

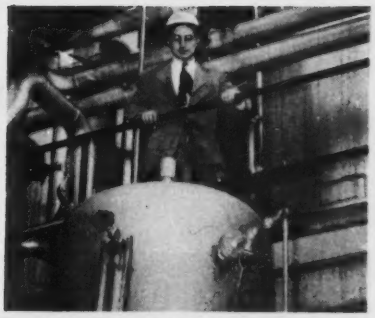
Dr. Konzak stated that as far as is now known the new strains have the desirable characteristics, including high yield, of the original Mohawk variety. These strains are being tested further. Studies are also in progress looking toward a better understanding of the genetic nature of the radiation-induced change, so these changes can be used to greater advantage in hybridization.

In his talk the Brookhaven scientist pointed out that the possibility of using radiations for the production of mutations has been known for many years. Some geneticists have felt that radiation-induced mutations are almost certain to be detrimental to the plant and, for this reason, the use of the radiation technique has not had ready acceptance by plant breeders in this country. However, in recent years, Swedish workers have succeeded in producing mutations in barley which are superior to the parent variety in yield as well as straw strength.

Dr. Konzak stated that the usefulness of the radiation method of inducing mutations is by no means confined to developing disease-resistant strains of oats. Also, the resulting mutations possess no radioactivity which would make them unfit for food purposes. Changes in a wide variety of plant characteristics might be caused in this way, leading to an improvement of many crops.

Dr. Konzak told how a program is now under way at Brookhaven National Laboratory, in collaboration with the Department of Agriculture and a number of state agriculture experiment stations. The object is to find beneficial characteristics in other varieties and in other crops. He emphasized that the radiation technique, however, is to be thought of as supplementing hybridization as a method of plant breeding. He felt that the use of neutron and other radiations to produce useful mutations in plants will play an important part in future plant improvement.

THE DU PONT DIGEST



George B. Bradshaw, Jr., *B.S. Ch. E., M.I.T., Asst. Supt., inspects a unit used in ammonia synthesis operation.*

Production Supervision

Requires Knowledge of Materials, Machines, and Men

Wm W. Kinsley, *M.S. in M.E., Penn. State 1949 (left), production supervisor in Du Pont textile fiber plant, is introduced to new operator by foreman.*

Keeping production rolling in a modern industrial plant is a job that appeals to men trained in many branches of science and engineering. If you are looking for opportunities in this field, you won't have to look far at Du Pont, where more than 1,500 members of the technical staff are engaged in production supervision.

To qualify, a man must be able to understand both the mechanical and chemical phases of production. In addition, he should be a good planner and, above all, have a knack for working with others.

Production supervisors are responsible for care of plant facilities, supply of raw materials, supervision of operation and maintenance, cost and shipment of finished products, as well as personnel relations, training and safety.

Since Du Pont makes over 1,200 products and product lines, it can offer many opportunities in a wide variety of operations to men interested in production supervision. In Du Pont's *Organic Chemicals Department*, for example, most technical men start in plant development groups, where they gain a background in both the technical and economic aspects of manufacture. Those with interests and abilities in production may then transfer to that field to acquire further, and more detailed, experience. Advancement leads to jobs as Building Supervisor, Senior and Chief Supervisors, and Superintendent.

The responsibilities of these supervisory levels vary, depending upon the men, the operation, and the products.

For example, in manufacturing dyes, up to 50 different operations may be carried out. Production and maintenance must be carefully planned and scheduled so that all needs for finished product are met. Temperature, pressure, and quality of reactants must be carefully controlled to insure that each batch of dye will match previous batches exactly.

In making each color, from 6 to 10 different unit processes may be called upon. And, in the course of time, all the unit operations known to chemical engineering come into play. Obviously, production supervisors have excellent opportunities to use and expand their technical knowledge and ingenuity. Equally important, they can acquire background and varied experience that prepare them for advancement to responsible positions in management and administration.

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The Sign of Value Around the World

2.54X

psychology, the machine and society

By Dr. Leonard Carmichael

Dr. Carmichael

Following is the text of the Eighth Annual Arthur Dehon Little Memorial Lecture, delivered November 17, in the Walker Memorial at the Massachusetts Institute of Technology by Dr. Leonard Carmichael, Secretary of the Smithsonian Institution.

Last spring in the sky over Korea when a pilot in one of our fast jet planes sighted an enemy jet approaching, he had to respond quickly, if at all. The human eye-nerve-muscle system requires at least one-fifth of a second to operate after such stimulation. If a directional movement trend in another plane is to be estimated, a much longer time is needed. During the period required for effective human response, two jets move hundreds of feet from where they were when the stimulation was initiated. In 1909 at the first Gordon-Bennett air race the winning plane averaged just over forty-seven miles per hour. Today plane speeds of more than fifteen times this rate are not uncommon, whereas the average speed of the operation of the human sense organs, brain, and muscles has not changed in these years. Indeed, it is very doubtful whether the best human reaction time of an ace pilot of the Korean war was different from that of a leading archer of the New Stone Age, when the bow and arrow had just been developed by the neolithic counterpart of our Atomic Energy Commission.

There is thus a hard reality behind some of the present-day lurid science fiction: Men have now made machines that are challenging the inborn anatomical and mental limitations of their masters. Furthermore, in the past few years increase in speed of travel, ease of world communication, potential military destructiveness, and the eradication and control of disease have violently upset the slowly evolved balance of the ages between the individual and his material and social world. These facts emphasized the need for a scientific consideration of man's fixed and sometimes inborn physiological and psychological capacities, in relation to novel and ingenious machines, to newly released energy sources, and especially to political and economic systems that are now so rapidly transforming the world.

Man had studied and speculated about his nature for many centuries. Probably ever since he first saw his reflection in a prehistoric pool he has wondered about himself. Throughout the ages, theologians, lawyers, physicians, philosophers, poets, myth-makers, and more recently anthropologists, psychiatrists, geneticists, physiologists, sociologists, and many other specialists, as well as psychologists, have pondered aspects of the great question: "What is man?" None has yet produced the final answer. Not even the most ardent present-day advocates of the usefulness of psychology would dream of maintaining that this one area of study alone can ever give a full reply to this obdurate riddle of the sphinx. Nevertheless, modern experimental psychology has developed some useful techniques and is still obtaining factual, fundamental information about human nature. The present-day relationship between human beings and machines and society is being made more understandable by this science in more than a few respects. When the student of mental reactions is asked, "What are the capacities of human individuals?" his answer today is far from complete, but it is possible to approach an answer, in modest, factual terms.

The wise psychologist does not attempt to predict the nature of the end products of human artistic creation, or try to determine the boundaries of man's highest intellectual potentialities or spiritual and aesthetic insights. Rather, psychologists try to describe, wherever possible in quantitative terms, basic mental processes, which

are often shown to be related to the anatomical and phsysiological living machinery of a unique primate called *Homo sapiens.*

Many questions similar to the following can be asked and to a limited degree answered by scientific psychology: "What is the average difference between man's fastest reaction to a sound and to a light?" "How fast and how accurately can different human individuals learn specific items of information, such as series of numbers?" "How rapidly does forgetting of specific new associations take place?" "How do individuals vary in the composite of abilities, sometimes called intelligence?" "What are the typical changes in the expression of emotion as an individual grows from babyhood to adult life?" "What is the effect of sleep deprivation on skilled motor performance?" "How is language related to thought?"

The extent of new knowledge in this field is illustrated by a handbook of "Human Engineering Data" recently published by Tufts College psychologists under contract with the Navy. This book, which has the external dimensions of the New York City telephone directory, is a compilation of the present state of useful psychological facts about the measurable traits and abilities of human beings. Its pages give hundreds of tables and graphs representing the results of experimental study of specific aspects of mental capacity. Many of the tables show averages and also give extremes of variation. In such studies of human mental characteristics, individual differences are recognized as important. There is no better established fact about men, women, and children than that variation is the most invariable law of nature. The amazing range of human capacity in any population is one of the first facts to be recognized by one who is concerned with making better machines for human operators or even with speculation about social, political, or economic theory or reform.

In general, therefore, the information made available as a result of experimental psychology is fundamental in concrete thinking concerning the present-day changing relationships between man and his world. The engineer who builds a new Diesel locomotive is limited by the properties of the materials he uses. The weight, tensile strength, heat resistance, elasticity, and other characteristics of the metals he employs do not predetermine the shape into which the material is to be fabricated. On the other hand, parts of such engines cannot be made of metals that have other than very specific characteristics. The same relationship holds for one who would consider how modern machines and present-day society are related to the inborn traits of every human being. "Which of you by taking thought can add one cubit unto his stature?" also applies to other characteristics besides height. The jet pilot, already referred to, cannot by thought, education, or wishing speed up beyond a certain fixed point the time his nerves must take in responding to external stimuli. Anyone concerned with the construction of new airplanes or with training pilots to fly such planes in formations, or with developing a better political or economic system, must not forget that physiologically and psychologically men have a large number of inborn capacities and many specific limitations.

As a first conclusion of this paper, therefore, may it be suggested that a modern and effective understanding of men will certainly involve a number of levels of study? Among the types of information that will be required in considering man's complex relationships to his total environment will be as accurate as possible a knowledge of the basic makeup of human beings.

Much more research in basic scientific psychology is therefore an urgent need of our age. "If only," says Prof. I. A. Richards (Harvard University), "something could be done in psychology remotely comparable to what has been achieved in physics, practical consequences might be expected even more remarkable than any that the engineer can contrive. The first positive steps in the science of the mind have been slow in coming, but they are beginning to change man's whole outlook." Our educational system, too, may well be planned so that proper and adequate training in psychology may be given and so that enough able young men and women in each generation are allowed an opportunity to become experts in this field. Experimental psychology and human engineering have contributions to make to machine design and what is more important even to social understanding.

Let us now look at the second noun of our title, *the machine.* Many of the pleasant and interesting, as well as many of the alarming, characteristics of our age are a direct result of machines and of other new processes and procedures following upon man's growing understanding of pure and applied science. The past fifteen decades have seen more developments which are based on quantitative and exact methods of studying nature than all preceding ages of history. During this period, in such societies as ours, science has made possible the release of man from drudgery in a way that was previously unthinkable. New sources of energy, and now atomic power itself, have been substituted for the old inefficient and painful work of human or animal muscles. Some great periods of the past were based upon the forced labor of mute human slaves. Today machines, our new and willing servants, relieve us from much of the relentless work that was accepted as inevitable by the unbroken line of our toiling ancestors.

Novel electronic systems are today being developed, for example here at the Massachusetts Institute of Technology, which will further lift the curse of drudgery not only from man's biceps and triceps but even from his mind. If human beings by their social blundering do not bring on war or political chaos and thus capriciously spoil this process, we may logically hope that the technology of the present and future will be even more humanly valuable than it has been in the past. It must be remembered also that advances in medical and public-health fields in the last generation have been without precedent. The average length of life has been increased and human beings have been relieved in an almost unbelievable way from much of their physical suffering, which, like muscular toil, had always before been accepted as the inevitable lot of all sons and daughters of Adam.

The support of research in pure and applied physical and biological science is thus eminently worth while. If society is to operate efficiently the

best modern psychological and personnel procedures must be used to discover in each generation those individuals who are best qualified to be educated so that they may in their turn carry on effective research and development in these fields. Such able individuals should also be encouraged to undergo the self-discipline and the training in mathematics and other basic fields of study required of those who are to do real research in science. This kind of preparation is absolutely essential to those who would wisely direct and maintain as well as develop the machines, processes, and services on which the modern world depends. Nature does not provide enough children in each generation who have outstanding mathematical and other academic aptitudes, as well as the personality characteristics necessary to become true modern scientists, to allow any to be wasted. It has been suggested that creative research of the highest order in the quantitative physical sciences can be expected only from selected individuals in the upper two percent of the population in measured intellectual ability. Such rare and valuable talent bearers should be nurtured and helped to use their inborn capacities for the welfare of our scientifically based age. The world cannot afford to squander its scientific manpower! It is particularly wasteful of human resources when individuals, recognized as singularly talented and perhaps well trained in certain scientific or technical specialties, are allowed or required either in military or civilian life to perform tasks that others can do as well or even better.

Dr. Arthur D. Little, again, saw with peculiar clarity the need of fostering able scientists. Men of science constituted for him a separate Fifth Estate in society. He said in a memorable paragraph: "This Fifth Estate is composed of those having the simplicity to wonder, the ability to question, the power to generalize, the capacity to apply. It is, in short, the company of thinkers, workers, expounders, and practicioners upon which the world is absolutely dependent for the preservation and advancement of that organized knowledge called science."

As a second conclusion of this paper, then, it may be suggested that society should give full attention to the discovery of human talent and to the effective education of promising leaders in pure and applied science and, it may be added, in other worth while scholarly fields. That all men are not born equally able to use mathematics is but one of many facts that must be accepted by those who are to plan wisely for the education of our youth for effective service to society.

From time to time we hear the monstrous notion proposed that a moratorium on scientific research should be established. Those who make such suggestions mistakenly blame science for our present social ills. Can anyone, however, with clear eyes doubt that the world now needs more, not less, science, and a wider, not more restricted, recognition of its implications and importance?

Men still ask themselves over and over again: Why have human beings who have made such good machines and such progress in understanding the cause and cure of many human illnesses, failed in creating a just and stable national and world social order? The author of this paper knows that he cannot answer this great question, but he still believes that it is worthy of the best thought of all of us. In the first place, the fact that the world has not yet developed a thoroughly workable political and economic organization cannot be blamed upon the failure of many men to consider the matter. For centuries philosophers, statesmen, political scientists, aspiring dictators, and even glittering soldiers of fortune like Napoleon have thought and talked about the need for social and political change and improvement on a world-wide scale. Sometimes it almost seems that society has suffered not so much because it has failed to consider its own improvement but rather because it has been tampered with by too many would-be reformers. Many of these advocates of social change have not understood or wanted to understand what we have called in this paper the basic nature of human beings.

The kind of thinking that has been so triumphantly successful in developing purely mechanical systems has not always worked when applied hastily to man's relationship to man. Edmund Burke, who was certainly one of the outstanding political scientists and philosophers of the eighteenth century, emphasized this fact. He spoke of ignorant men who were not fools enough to meddle with their own clocks but who still felt free to advocate the taking apart of society, and the disrupting of its immemorial springs, balance, counteractions, and cooperating powers.

For years sociologists have said that in some respects society is like an organism. This analogy may be carried too far, but it does seem to be true that in old and well-established communities there is an almost organic unity in the structural pattern of social living. Successful, modern physicians do not try to create new organisms in the place of the patients they are called upon to treat. Medicine rather has learned to alter the processes that interfere with health and to recognize that a real cure is usually the result of restorative processes inherent in the body. These processes may be thought of as part of the body itself and have been produced by millions of years of organic evolution. This approach of the modern medical scientist may have a lesson for the social and economic reformer. Today, however, looking back at the social changes that have been advocated in the relatively few years since the French Revolution, one can hardly escape the conclusion that would-be social doctors have all too often tried to put together a new society and not to cure the old one. They seem not to have realized that some aspects of man's social organization like the human species itself have grown by the slow evolution of possibly a million years of man's living with man on this planet. Some inborn and essentially unchanging physiological and psychological characteristics of the human organisms make certain social patterns more effective than others.

Social advances in recorded history there certainly have been. Democracy as we know it at its best is an example of such progress in man's estate. The abolition, in many parts of the world, of human slavery is another sure advance. It is distressing to realize, however, as we think of both democracy and the abolition of slavery, that we are living in an age in which new patterns of dictatorship and of human servitude are again being fostered by some of those who talk most

loudly about creating society on a new mechanical plan.

In view of our present world conditions it is surprising to remember that many of our academic parents and grandparents convinced themselves that all or almost all social change of any sort was real social progress. Many of them had the simple faith that various types of social disruption, which they advocated, would lead to social uplift for the benefit of mankind everywhere. Some Victorian intellectual leaders adopted uncritically what now seems to have been a deceptively attractive general idea. They looked at the most external aspects of Darwinian biological evolutionary theory and then suggested that the same factors which were assumed to have operated during millions of years in the development of species of plants and animals could be counted on in a few decades of human planning, or telic social evolution, to establish a wholly new society. These reformers never dreamed of the difficulties of our age that followed the social upheaval they did so much to promote. In nineteenth century England many academic reformers cheered in a polite way as the age-old influence of the Established Church and of religion in general was being undermined. They saw only good in the passing of the remnants of the ancient stratification of society. They closed their eyes to the fact that many of those who were born to so-called special privilege traditionally recognized that they had inherited, along with the rights and status of their class, certain inescapable social obligations. The reformers who rejoiced most at the passing of the established order did not have clear enough eyes to foresee that the theory of social change they advocated would later be stretched to form a basis for a police state and the denial of human personal liberties.

As Dr. Russell Kirk has recently sagaciously and persuasively pointed out, from the time of the French Revolution on there have been those who have seen the dangers inherent in unbridled social change. John Adams, our second President, was such a philosopher. So was the often misunderstood English statesman Disraeli, and in a very different way, Matthew Arnold. There have been many others. In more recent times George Santayana, Irving Babbitt, Paul Elmer More, T. S. Eliot, and Peter Viereck have made clear some of the errors in much of the thinking of the socialists, collectivists, and disrupters generally.

Jeremy Bentham, John Stuart Mill, and other utilitarians and fabian socialists were great hands at suggesting how Humpty-Dumpty-like human society could be broken apart. It now seems that they, like all the king's horses and all the king's men, were not equally good at suggesting means by which the organic structure of our slowly evolved society could again be regenerated after it had been shattered. Not a few modern thinkers agree, and with some reason, that our civilized world owes many of its worst disorders to the verbal blandishments of the romantic writings of Rousseau. Certainly no philosopher ever espoused a much more unrealistic psychology of human nature than did this brilliant vagabond and revolutionary thinker. After the fall of the old regime in France a whole succession of dreamers, utopians, and sentimental socialists in various countries, often explicitly influenced by Rousseau, advocated turning many of the established laws and principles of society upside down. The idea that a freely competitive economy is a high expression of man's inborn nature seems currently to be gaining ground as the practical impossibilities of the so-called classless society of socialism or communism are disclosed. That the legal sanctity of private property is a prime guarantee of our human freedoms is probably better recognized today than at any other time in the past century.

Even the late Maynard Keynes, not always the most conservative of economists, recognized the point of view here being considered. Dr. Kirk, in his recent admirable book, The Conservative Mind, quotes Keynes as saying: "Benthamism I do now regard as the worm which has been gnawing at the insides of modern civilization and is responsible for its present moral decay. We used to regard the Christians as the enemy, because they appeared as the representatives of tradition, convention, and hocus-pocus. In truth it was the Benthamite calculus, based on over-valuation of the economic criterion, which was destroying the quality of the popular Ideal." Kirk summarized Keynes as asserting that "the final *reductio ad absurdum* of Benthamism is known as Marxism; drained of spirit and imagination by the gross objectives of the Utilitarians, we have ended defenseless before this brutal descendant of Bentham's philanthropy."

In many places today therefore a new conviction is growing that what ails our age is not some ancient political, economic, or social cancer, but rather a loss of the old understanding that virtue in the individuals who make up society is basic in creating a good, just, free, and achieving social order. The rash theorists and self-seeking politicians who have attacked existing organic social orders have often sneered at this age-old idea. For example, many of the self-styled liberals of the nineteenth century believed that a society could exist without religion, but this assumption has never been demonstrated through a series of generations. They also underestimated the importance of the slowly evolved traditional wisdom of mankind and the power of custom, that universal gyroscope of society, in the effective control of human beings and especially in the ordering of the lives of those of limited capacity in the use of abstract verbal principles. Practical ideals and a fixed scale of human values were recognized, taught, and acclaimed, if not always lived up to, by the old system. Politeness and courtesy, sometimes called the minor morals or the lubricants of society, also were handed down from the past to make social living more pleasant. All too often these intangible and in some respects truly spiritual characteristics of man's ancient mores were thrown out by its sudden would-be reformers with their superficially mechanistic ideas. There were, to be sure, injustices and inequities in all the old orders of society. But those who saw reform as the mere provision of more and more superficial entertainment and greater and greater idleness for larger and larger groups of people were set, it now appears, on copying the worst and not the best of the old society they were trying to over-

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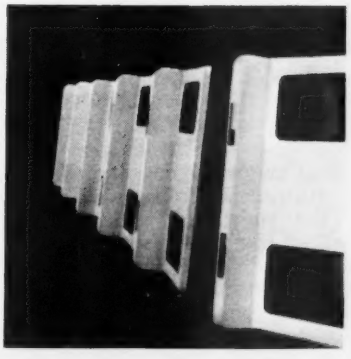

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turn. As hours of work were decreased and pay increased the economic feasibility of skilled handwork and its consequent artistic satisfactions to the worker were largely lost. It is a sad commentary that sometimes this precious new leisure has been occupied by activities no more constructive than wagering on dogs as they run after mechanical rabbits.

Thus we return to the strange fact that men who have learned to release atomic energy, to bounce signals back and forth from the moon, to banish typhoid and yellow fevers, and to make electronic calculators do the work of tired brains, have failed to maintain the best intrinsic satisfactions, the highest ancient ethical and moral values and spiritual insights, in a changing society. It is all too clear that some of the would-be doctors of society, unlike modern scientific physicians, failed to recognize that human beings are not all alike and that they have inborn characteristics that must be dealt with by those who would effectively improve society.

We are faced back to the conclusion that the basic psychology of those parts of human nature that are inborn ought not to be forgotten by the successful social engineer any more than the properties of metals can be disregarded by one who plans to construct a good television receiver. As Lewis Mumford once put it, in an address before the American Association for the Advancement of Science, "The tendency to overlook the human end which our automatic organizations serve has begun to pervade our whole civilization; and in the end, if it is uncorrected, it may effectually undermine our best achievements . . . No matter how marvelous our inventions, how productive our industries, how exquisitely automatic our machines, the whole process may be brought to a standstill by its failure to engage the human personality or to serve its needs."

Radical social reformers have often tried to pretend that biological heredity was not important in psychology. William Godwin, a most fixed-eyed and unrealistic but strangely influential social reformer of the late eighteenth century, believed in the perfectibility of the human race in one generation if the environment could only be changed in the right way. Many later would-be reformers have unthinkingly accepted this view. Even the great John Stuart Mill suggested that anyone who believed in inherited traits was an advocate of social reaction. In our own time this old scientific heresy, that inborn differences between men of the sort measured by aptitude tests do not exist, is still proclaimed as a new truth in Russia. In holding this position at least at the verbal level, the steel-handed present-day Russian Communists are walking in the path of the visionary nineteenth-century melioristic reformers who preceded them. Intelligence tests in education are now proscribed by Moscow. Such measuring devices are said to demonstrate differences that cannot exist in the so-called perfect environment of a communist state. It would be interesting to know through what back door a realistic recognition of inborn individual differences is now introduced in Russian education. That such differences exist in Russia as well as in America is as sure as is the existence of chromosomes. It is true, of course, that modern psychology must deal with both inborn and culturally determined traits, for ordinarily both chromosomal determination and environmental forces cooperate in producing each physical or mental performance of every person. But to ignore inherited differences in individuals is to close one's eyes to most important facts.

Is it not fair to say, therefore, that one of the worst mistakes of the superficially mechanistic reformers of society has been their willingness to forget that society is made up of individual free organisms with conservative and yet varying brains and muscles? To put this in in another way, is not a good society made up of bad individual men impossible? Certainly this is true, in spite of the satirical arguments of such tongue-in-cheek philosophers as Bernard de Mandeville who have attempted to assert that private vices make public benefits. A group of people of varying inborn abilities but alike in trying hard to be honest, unselfish, charitable, virtuous, diligent, self-reliant, and full respecters of private property, would not need to worry too much about external sccial or economic reform.

This point of view makes it clear that what Peter Viereck has well called the "revolt against revolt" should now challenge our full attention. Have we not been living too long in a world that has tried to pretend that social upheaval is always social progress? Destructive social reformers often have sweet tasting and mysterious medicines to propose. Such men in our time begin by suggesting new legislation that seems to give something for nothing. Harold Laski, for example, always could attack what he called "privilege" as he advocated more socialization of industry. Envy may for a time be a satisfactory motive to be used by the selfish demagogue to get votes, but it is a bad sentiment on which to build a stable and achieving society. When legislation does not produce the results hoped for by the reformers more and more police action is demanded. Those, however, who see that the organic structure of society must be maintained and slowly made better by improving the personal character of individual human beings are at a disadvantage in combating the schemes of the wholesale destructive advocates of social change. Those who believe in self-discipline first have no simple and easy patent medicine to prescribe. All that such conservative and true reformers can suggest is more adherence on the part of more people to the highest ethical and religious teachings and more of the right sort of education fitted for individuals of differing interests and inborn talents. Social improvement of this sort is usually within the reach of every individual, but it requires first the hard work of self-reform and not the iconoclastic fun of pulling down others who externally seem more fortunate or who have been more diligent and thrifty.

When we think here of the education of individuals let us not forget that the objectives of education are in the last analysis socially determined. In our political democracy and our tested and effective, competitive, free, capitalist economy we all have a responsibility to see

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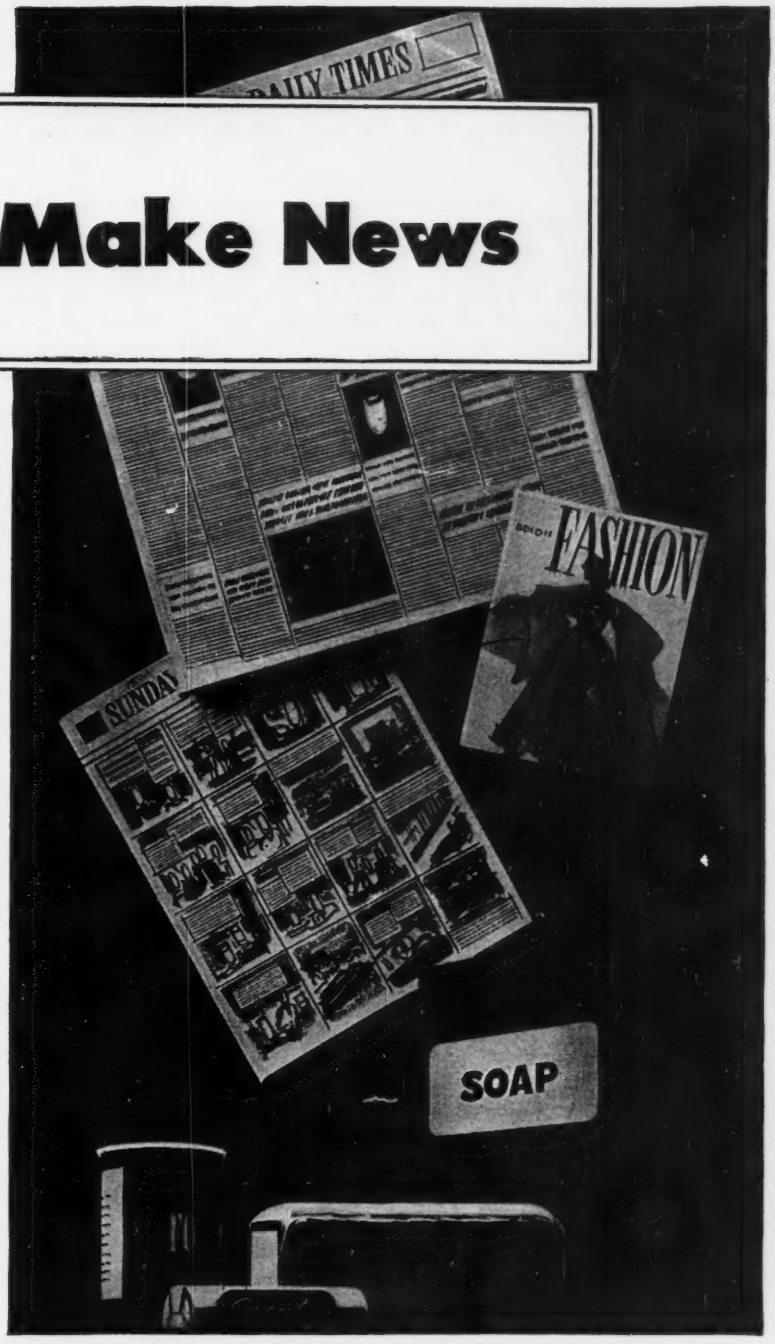

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to it that our schools foster an education that makes possible the discovery of truth and the achievement of individual intellectual liberty. Harvard University's now justly famous book "General Education in a Free Society" wisely begins with these words of Plato: "Youth is the time when the character is being molded and easily takes any impress one may wish to stamp on it. Shall we then simply allow our children to listen to any stories that anyone happens to make up and so receive into their minds ideas often the very opposite to those we shall think they ought to have when they are grown up?"

If this statement from the *Republic* is accepted we are today challenged to re-examine the question as to whether, under the influence of a shallow and often misunderstood positivism and an incomplete naturalism, American education has not in the past generation turned too sharply away from all instruction that had as its aim the inculcation of fixed systems of values. If a free and stable society depends on citizens who act as they do because they are trying hard to live up to high ethical standards, then let us do what we can to raise up new generations that know what these standards and scales of values are.

It is easier, of course, to talk about the teaching of ethical and even esthetic values than to say how such instruction should be given in a free democracy. Certainly, however, an education aiming to accomplish such ends will emphasize studies that acquaint the members of each new generation with the true wisdom of the race concerning the best ways in which men can react to one another. The study of biology, anthropology, sociology, economics, political science, social history, psychiatry, and psychology will help in providing a basis for this understanding. But these fields alone will not provide the needed humanistic value scales because in their very nature these sciences must be objective and factual.

The conclusion seems forced upon us, therefore, with new inevitability that an education which is to make free, sensitive, socially responsible individuals with self-accepted value systems must emphasize the great body of studies, such as religion, law, history, and literature, that represents the noblest human wisdom of the past—"the best that has been thought and said in the world." To put this another way, it seems that the education of individuals who are to have the persistence, the courage, and the stamina to reform themselves before they try to reform society will require a sympathetic study of the best parts of those strands of our intellectual tradition which we call the humanities.

This conclusion, of course, is not novel. Students here at the Massachusetts Institute of Technology are naturally and most properly offered unsurpassed opportunities to study the physical sciences and the whole range of modern applied technologies. In recent years, however, under the far-sighted educational statesmanship of Dr. Karl T. Compton and President James R. Killian, Jr., this world renowned scientific research institution has emphasized basic instruction in the humanities. Thus an effort is made to have students here become not only scientists and technologists but also wise human beings who understand the intellectual, artistic, and spiritual traditions and values that mankind has gradually beaten out for itself through the ages. This fortunately is a point of view in higher education that today is sweeping to new recognition everywhere in America. The old destructive educational revolution of the last generation that tried to banish values from school and college work is being unmasked as a destroyer of much that was of first importance to a stable and achieving society.

In this great institution, and in others like it that are hospitable to many foreign students, it is good that this new point of view is being emphasized. Visiting students from other lands and cultures should not only be given our mathematical, scientific, and technological skills, but also should learn the true spiritual wisdom of our free western world at its best.

Therefore, in recapitulation, as we think of psychology, the machine, and society, a few basic conclusions emerge. Science in a most general sense has given great sections of modern men a high standard of living and an opportunity to provide themselves a life of health and comfort undreamed of in any ancient utopia. Further progress of this kind may be confidently expected if social and international disorder does not prevent it. Modern psychology, although still far from being able to provide final answers to all relevant questions, does show that man's understanding of his inborn and acquire make-up is important for technology and an understanding of society.

In spite of these demonstrated advances, pessimism about society is a dominant attitude of many thoughtful people in our day. Recent social upheavals aggravate this gloomy stand. Is it not conceivable, however, that in their faith in the possibility of social progress, Victorian intellectual leaders were nearer the truth than are some of our modern writers?

Man's mammalian characteristics are millions of years old, but man as a free intelligence is built to live in the future. The pilots of the atomic-powered airplanes of the year 2000 will have essentially the same conservative brain and muscles that our fathers possessed. Nevertheless, our growing knowledge of psychology, the machine, and society seems ready to help us make such future pilots and others of their generation ethically and socially wiser and more satisfied with life than we are. If we are to approach this better it seems clear that we must be prepared to spend more money and thought than in the past on improving the quality of the instruction we offer to all the youth of our race. If we hope to have a finer and more achieving society, education fitted to the aptitudes of each individual is a most promising tool. As we plan for the future place of education in our social order, let us have the courage to act as though we believe that the golden age is ahead and not behind!

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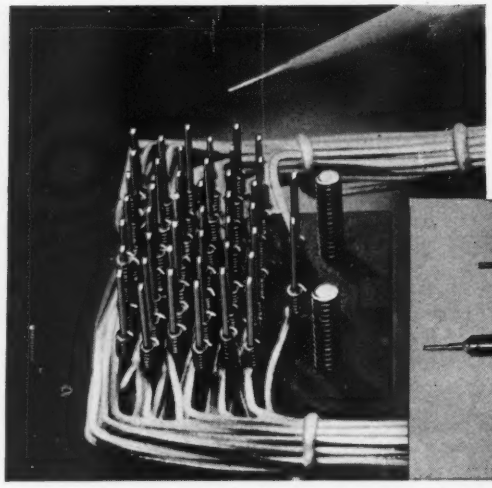
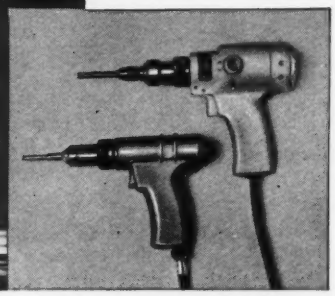


New solderless method permits the making of very closely spaced connections, as shown on this experimental terminal block.



Electrically powered "wire wrap" tool (above) and compressed air tool (below) for making wrapped solderless connections.

GOOD CONNECTIONS are mighty important to us for, you see, we make more than a billion electrical connections each year. It takes that many to manufacture and install complex telephone equipment in the Bell System.

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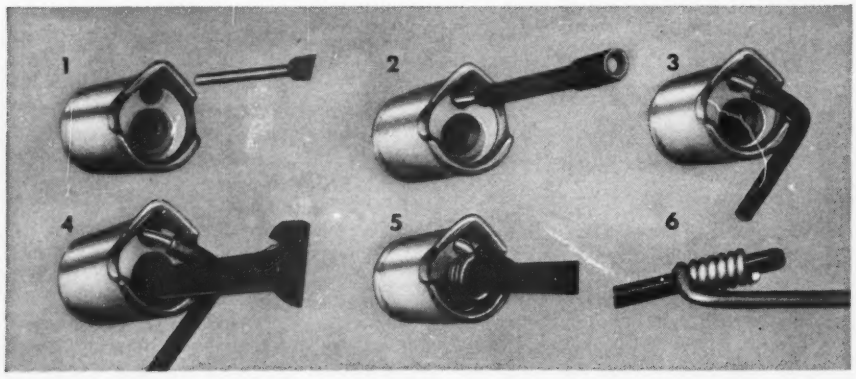

How a solderless connection is made: (1) Skinned wire approaches the small flared opening in the tool tip. (2) Wire is inserted in hole. (3) Wire is bent and anchored by means of notch in side of gun tip. (4) Gun tip is slipped over rectangular wire terminal. (5) Spindle of gun tip rotates to wrap wire around terminal. (6) Six wire wraps around terminal complete electrically sound joint without soldering.

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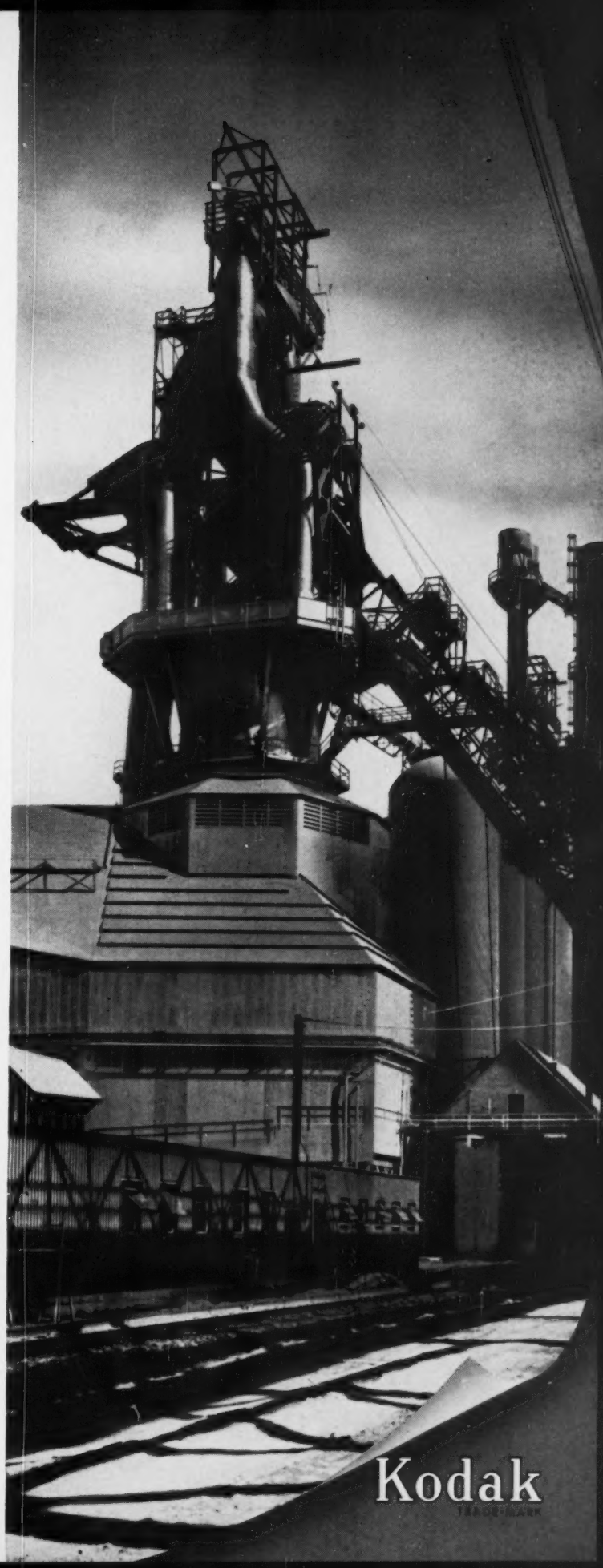

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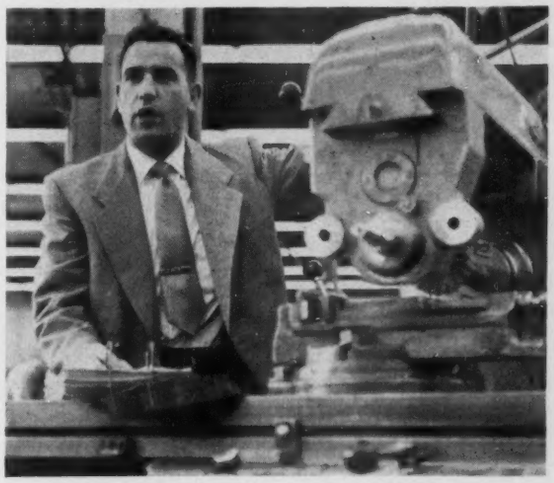

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